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Pechan (E.H.) and Associates, Inc., Durham, NC

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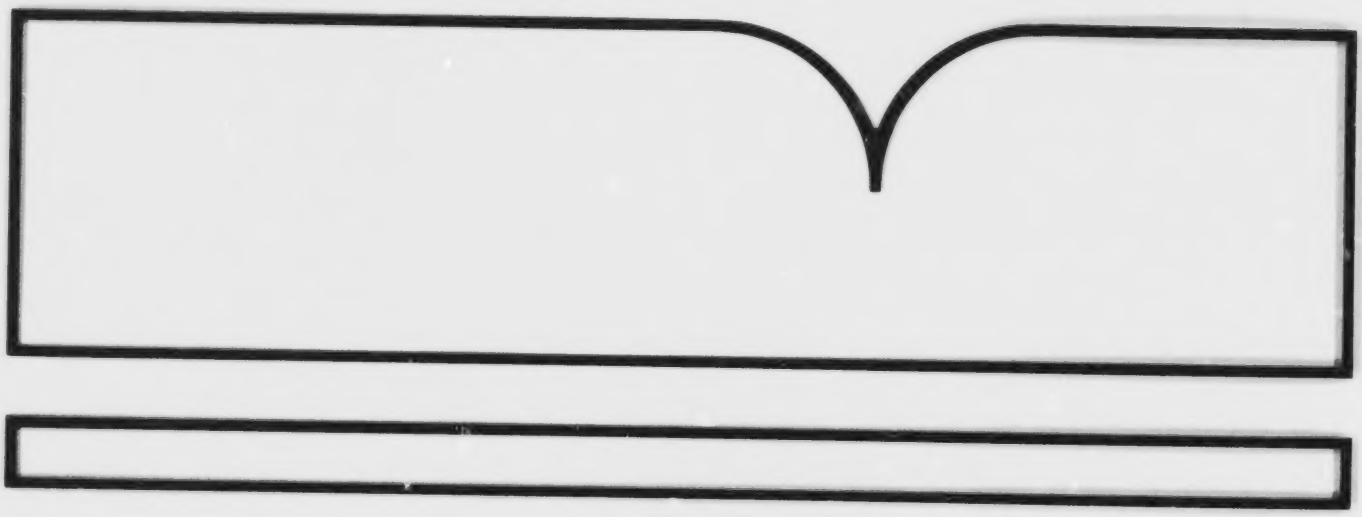

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16. ABSTRACT The report gives results of a comparison of historic SO2 and NOx emission data sets. During the past few years, several research projects have been conducted to reconstruct historic air pollution emission trends in the U.S. This report compares in detail the emission estimates derived by G. Gschwandtner and coworkers and by R. Husar, and attempts to determine the methodological differences that result in different emission estimates. In addition, the U.S. EPA historical trends, the electric utilities emissions estimates and the NAPAP monthly trends inventory are compared to Gschwandtner's inventory. The inventories' differing objectives and reasons for slightly varying emissions estimates are explained. On the national level, all estimates are in reasonable agreement. One objective of this study was to determine a basis for changing any of the existing estimates in order to minimize or eliminate unnecessary differences in reported national total emissions for common years. Revised NOx and SO2 emission estimates, based primarily on Gschwandtner and EPA trends, are recommended for use in future analyses utilizing historic emission estimates.

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COMPARISON OF HISTORIC SO_2 AND NO_x EMISSION DATA SETS

by

Gerhard Gschwandtner and Janice K. Wagner
E.H. Pechan & Associates, Inc.
Durham, North Carolina 27707

Rudolf B. Husar
Washington University
St. Louis, Missouri 63130

EPA Contract No. 68-02-4271
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J. David Mobley, EPA Project Officer
Air and Energy Engineering Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

This work was conducted as part of the National Acid Precipitation Assessment Program

AIR AND ENERGY ENGINEERING RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

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FOREWORD

This report compares various estimates of historic emissions of sulfur and nitrogen oxides in the United States since 1900. The estimates compared were prepared independently by different researchers as fulfillment of different research objectives for the U.S. Environmental Protection Agency (EPA), the National Acid Precipitation Assessment Program (NAPAP), and the National Academy of Sciences. All of the emission inventories compared in this report, with the exception of the estimates of Husar and Knudson, were supported with funds provided by the U.S. EPA through NAPAP. Husar's work was conducted independently with some support by the National Academy of Sciences. Additional support was provided Husar by the U.S. EPA for his participation in this study. Knudson's research was supported by the U.S. Department of Energy, also through NAPAP.

Section 2 of this document was prepared in conjunction with Rudolf Husar. All other sections were prepared by Gerhard Gschwandtner and Janice Wagner.

ABSTRACT

During the past few years, several research projects have been conducted to reconstruct historic air pollution emission trends in the United States. This report compares in detail the emission estimates derived by Gschwandtner et al. and Husar and attempts to determine the methodological differences that result in different emission estimates. In addition, the U.S. EPA historical trends, the electric utilities emissions estimates, and the NAPAP monthly trends inventory are compared to Gschwandtner's inventory. The inventories' differing objectives and reasons for the slightly varying emissions estimates are explained. On the national level, all estimates are in reasonable agreement. One objective of this study was to determine a basis for changing any of the existing estimates in order to minimize or eliminate unnecessary differences in reported national total emissions for common years. A revised set of NO_x and SO_2 emission estimates, based primarily on Gschwandtner and EPA trends, is recommended for use in future analyses utilizing historic emission estimates.

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SECTION 1

PROJECT SUMMARY

The National Acid Precipitation Assessment Program (NAPAP) was established by Congress to conduct research on the causes and effects of acid precipitation. As part of this program, NAPAP's Emissions and Controls Task Group was formed to provide information on anthropogenic sources of air pollution emissions. Several types of emission inventories have been produced to meet the various research needs of other task groups studying different aspects of the acid precipitation phenomenon. These include an extensive inventory for 1980 and historic inventories that span various periods of time. The historic inventories developed under NAPAP and the EPA support are summarized in Table 1. In addition, an inventory of historic SO_2 and NO_x emissions was prepared independently by Husar for the National Academy of Sciences.[2]

Each of these inventories was developed to meet a different research objective. Each was based on a methodology most appropriate to achieving that objective. As a result, the methods and estimating techniques are slightly different, yet they yield similar estimates of emission trends. This report attempts to identify the reasons for the differences and to resolve them.

The major objective of each set of historic emissions estimates is described below.

Gschwandtner et al.[1]

The main objective of this inventory was to produce historic state level emission estimates of SO_2 and NO_x in a consistent manner that could be used as a common data set by various research groups in NAPAP.

Husar[2]

The main objective was to develop methods for determining the trend in historic sulfur emissions and to explore the uncertainty of the emission estimates using various alternative methods and information.

U.S. EPA Trends[3]

The main objective is to update the national emission trend for all criteria pollutants on an annual basis for previous years.

TABLE 1. AVAILABLE HISTORIC EMISSIONS ESTIMATES

Pollutant	Categories	Period	Temporal Resolution	Geographic Resolution	Reference
SO_2, NO_X	All	1900-1980	Annual	State Level	1--Gschwandtner
SO_2, NO_X	All	1890-1981	Annual	State Level	2--Husar
All Criteria Pollutants	All	1940-1985	Annual*	National	3--U.S. EPA
SO_2, NO_X	Electric Utilities	1975-1983	Annual	Plant Level	4--Pechan
SO2, NO_X	Utilities Non Utilities	1975-1984	Monthly	State Level	5--Knudson

* Available for 1940, 1950, 1960, 1965, and yearly from 1970 to 1985.

National Electric Utility Emission Estimates[4]

The main objective of this file is to provide accurate SO_2 and NO_x emission estimates for individual power plants.

Monthly Emissions[5]

The objective of this inventory is to provide monthly, state level emission trends of SO_2 and NO_x.

Given different objectives, different technical approaches were developed. Each approach necessarily required different input information. As a result, the total aggregated emissions estimated by each study are similar, but not identical. Figures 1 and 2 compare the total national SO_2 and NO_x emissions reported by the different studies. Figure 3 presents the revised emission estimates of Gschwandtner which reflect the EPA trends data.

This report examines the differences between the various historic emission estimates in detail, in order to understand and explain the differences. In addition, an attempt has been made to estimate the uncertainty of historic national emissions estimates.

Conclusions

1. The approaches used by Husar and Gschwandtner to develop historic SO_2 and NO_x emissions are comparable and their estimates are similar when adjusted for differences in source category accounting.

2. Sulfur content of coal mined and shipped is about 20 percent higher than the sulfur of coal consumed, according to information reported by the U.S. Department of Energy. This discrepancy could not be resolved in this study. Further investigation is needed to determine if, in fact, more sulfur has been emitted than is accounted for by consumption based sulfur data.

3. The uncertainty methodology and the input data required for uncertainty estimation should be refined for application to the historic emissions inventory.

4. An analysis of the uncertainty associated with total national SO_2 emissions suggests that the uncertainty is primarily affected by uncertainty in coal sulfur content. Applying this preliminary uncertainty analysis to the methods used by Husar and Gschwandtner as an illustrative example of uncertainty estimation, results in a calculated range of 31 to 45 percent uncertainty in these historic SO_2 emission estimates.

5. A similar analysis of the uncertainty associated with total national NO_x emissions suggests that this uncertainty is

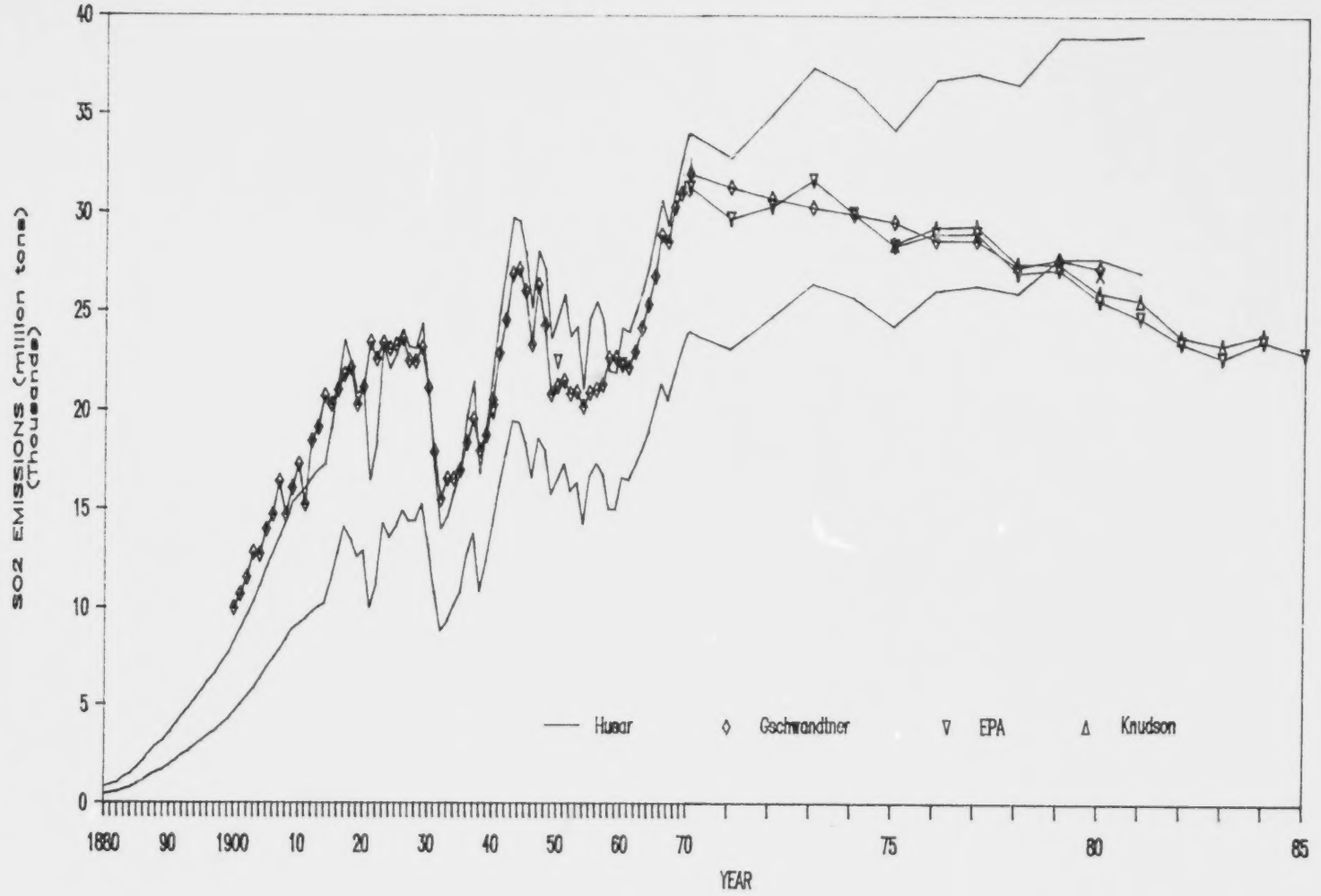

Figure 1. Comparison of total SO_2 emissions estimated by different studies.

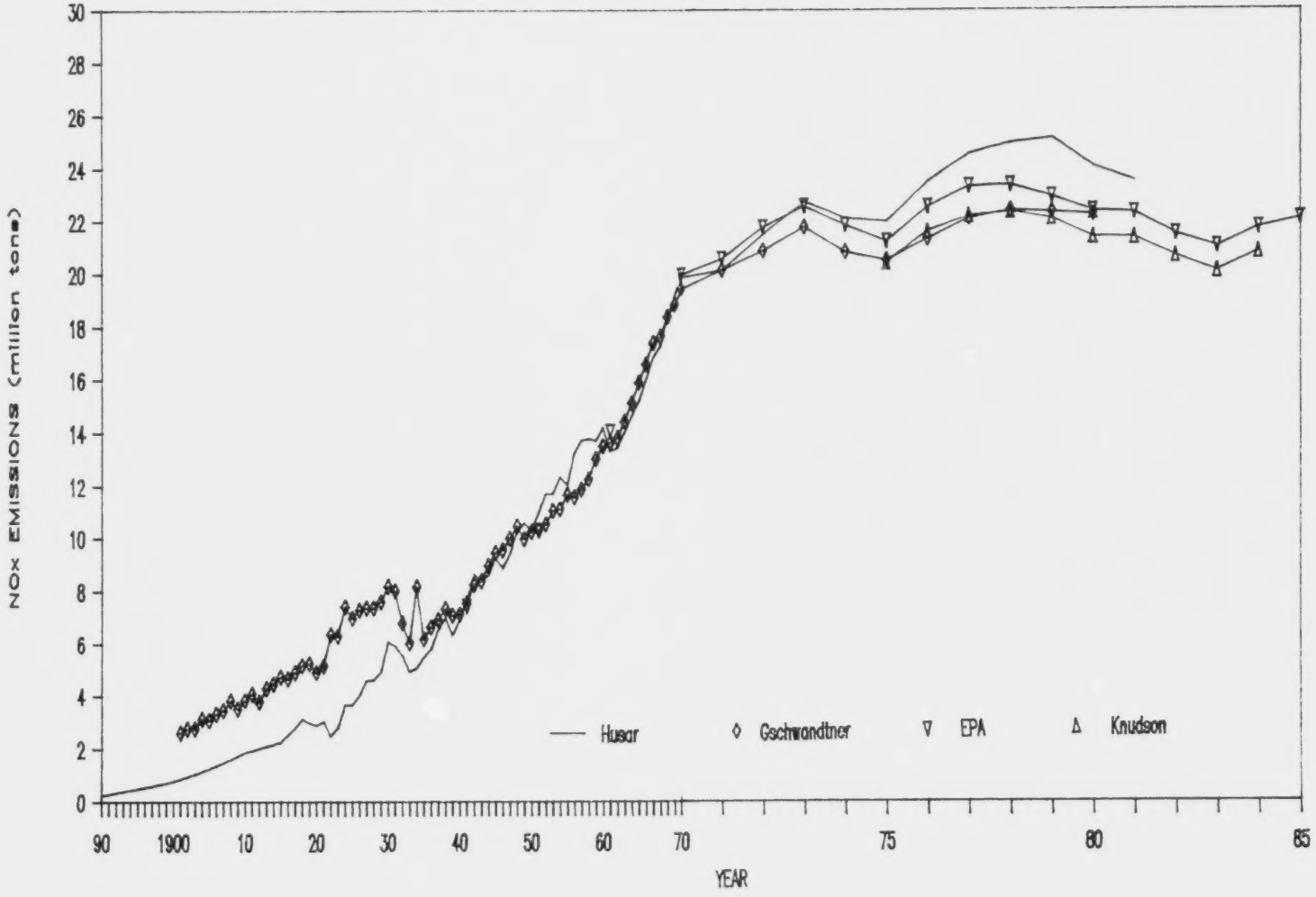

Figure 2. Comparison of total NO_x emissions estimated by different studies.

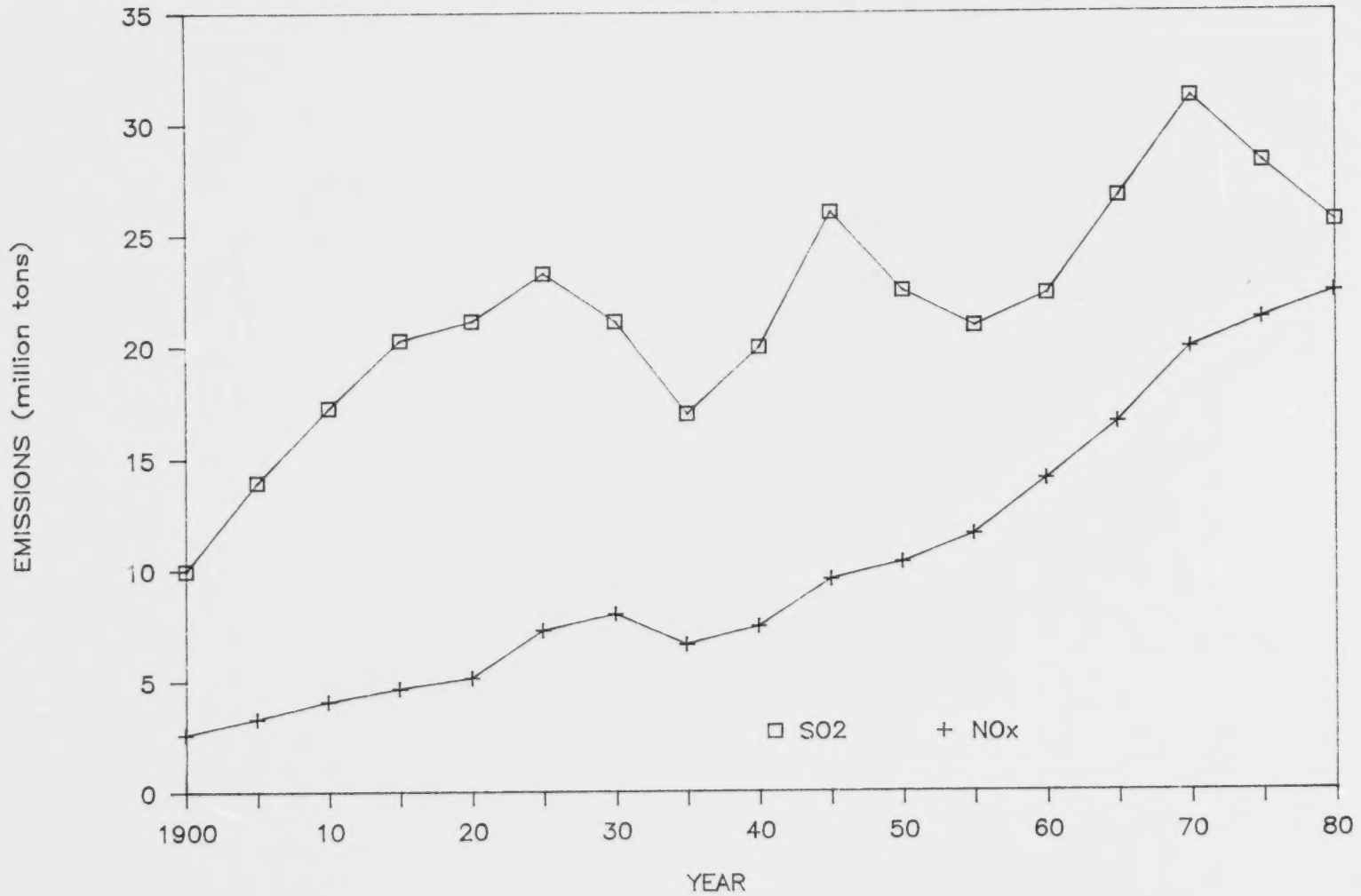

Figure 3. Revised SO_2 and NO_x historical emission estimates.

dominated by the uncertainty in historic NO_x emission factors. Applying this preliminary uncertainty analysis to the methods used by Husar and Gschwandtner as an illustrative example of uncertainty estimation, results in a calculated range of 16 to 38 percent uncertainty in these historic NO_x emission estimated.

6. Because differing historic emission estimates have caused confusion among NAPAP researchers, the historic state-level emission estimates of Gschwandtner et al.[1] have been adjusted so that the aggregated total is identical to the U.S. EPA national emission estimates[3] less states and territories outside the contiguous United States.

7. For 1986, the U.S. EPA trends methodology was changed so that it accounts for the same FGD removal as the Pechan electric utility emission estimates. The revised methodology will also be applied to future years. For years prior to 1986, the national emission factors obtained from the Pechan inventories were incorporated in the Trends calculations. As a result, the U.S. EPA trends for electric utilities and the Pechan estimates are identical.

8. The users of historic emissions data should understand the differing purposes of the various inventories and select the best inventory accordingly.

As a result of the present study, all emission inventories[1-5] are in agreement regarding the total national emissions. While some differences have existed in the past regarding the exact quantity of total national emissions, the differences have been studied and adjustments have been made to yield a single annual national total emission estimate for NAPAP. As a result of this comparative study, the adjusted inventory presented in Appendix A is recommended for use by NAPAP for the best estimates of long-range (back to 1900) annual emission trends.

SECTION 2

COMPARISON OF HUSAR AND GSCHWANDTNER EMISSIONS ESTIMATES

OBJECTIVE

The objective of this study was to compare the methodologies used by Gschwandtner et al.[1] and by Husar[2] in the reconstruction of state level SO_2 and NO_x emissions for 1900 to 1980. Since these inventories were developed independently, it was considered beneficial to investigate similarities and differences in the methodologies in an attempt to produce better and more consistent historic estimates. Given the different approaches, this investigation provided a unique opportunity to begin to determine the uncertainty of the estimates and to provide a means of quality assurance.

BACKGROUND

The development of both historic SO_2 and NO_x emission inventories began in 1980. By the late 1970s Husar et al. had studied the relationship between sulfur emissions and visibility.[6] Husar used coal consumption data as indicators of sulfur emission trends until his historic emissions study, which involved analyses of coal production, distribution, and consumption on the regional level, and the mobilization of sulfur. Husar used a material balance approach to determine the flow of sulfur from coal producing districts to final emissions sources on the state level. Having previously prepared extensive data bases on fuel consumption, Husar was able to estimate NO_x emissions using assumed emission factors that are time-variable to reflect changes in combustion technology.

In 1980, under contract to the U.S. EPA, Gschwandtner et al. began to estimate SO_2 and NO_x emissions from all types of fuel combustion sources from 1950 to 1978 for 33 eastern states.[7] Emissions were calculated for individual source categories such as electric utilities and industrial boilers for each fuel type. The calculation involved multiplying fuel consumption by an emission factor specific to each source category and, in the case of SO_2, a statewide sulfur content value of the fuel for the particular category. In 1984, Gschwandtner et al. extended the estimates to cover the 1900-1980 time period for all states and further improved the level of detail in the methodology.[1]

The Husar and Gschwandtner methodologies involve determining the amount of fuel consumed on the state level and the associated amount of sulfur and nitrogen released into the atmosphere. Differences in the methodologies result primarily from calculating sulfur content of consumed fuel in different ways and accounting for different source categories.

Differences In Research Objectives

There are substantial differences in the specific goals set for the Gschwandtner et al. and Husar data sets. Gschwandtner's goal was to prepare an inventory that can be used as an operational data base by many researchers in the NAPAP. Husar's inventory was designed as an emission model with the goal of exploring the basic assumptions and uncertainties in the emission estimates. Consequently, there are a number of differences in the two approaches that are relevant to the comparison.

1. The Gschwandtner inventory was designed as a static data set that can be utilized by the various research groups in NAPAP. The requirement for this purpose was that the inventory uses "best available information and knowledge" and it remains unchanged for a number of years. The Husar inventory was designed to be a dynamic model that facilitates the exploration of various assumptions and uncertainties.

2. Gschwandtner used a single method of calculation for each variable affecting the emission rate, comparable to the U.S. EPA method for calculating emission trends.[3] This produced a single consistent data set. Husar used alternative methods to explore the implications on the emission estimates.

3. Detailed evaluation of the uncertainty was beyond the scope of the Gschwandtner et al. report. In Husar's analysis it has been the main objective.

4. Gschwandtner invested substantial effort in preserving the detail of source categorization that is characteristic of many EPA emission inventories. Husar has lumped the source categories focusing on the total fuel consumption by all sources.

5. Gschwandtner evaluated the consumption and emissions of many individual source categories every fifth year to characterize the trends. Husar calculated yearly trends of consumption and emissions primarily for total fuel combustion.

6. As a consequence of point 1, Gschwandtner inventory was assembled through a "hard coded" program, while the Husar inventory is implemented as a set of LOTUS 123 spreadsheets that facilitate graphical analysis and analysis of various scenarios. (The Gschwandtner inventory has been modified as described in Section 3, and is available in spreadsheet form.)

7. The Gschwandtner inventory is the historic emissions inventory recommended for use by NAPAP researchers. It is distributed through the National Technical Information Service (NTIS) in paper and digital form. The Husar data set and emission model is distributed on an ad hoc basis to interested researchers.

In 1987, Husar and Gschwandtner had an opportunity to compare their methodologies and results in detail. Their comparison provided a chance to investigate differences of historic emission estimates. Their findings are summarized below.

Timeframes and Resolution

Husar estimated annual emissions for each year individually. The estimates were based on yearly fuel consumption and yearly sulfur values and emission fractions. Gschwandtner calculated the annual emissions in detail for every fifth year for each source category. For the intervening years, he used a method of interpolation based on annual national energy consumption by fuel type. As a result, both emission estimates are available year-by-year. Husar's estimates begin in 1890 and Gschwandtner's begin in 1900.

COMPARISON OF SO_2 EMISSIONS

The comparison of Gschwandtner et al.[1] and Husar[2] historic emissions involved a systematic re-examination of the underlying data bases. Differences in source category definition, activity data, fuel sulfur content, and emission factors were examined for selected states and for the contiguous United States. Figure 4 compares the total SO_2 emissions reported by Husar and Gschwandtner et al. The figure shows a true plot of the actual reported estimates of each researcher. It is significantly different from the figure published by the National Academy of Sciences. The National Academy report showed much lower estimates for Husar than is actually the case.

The total SO_2 emissions of Gschwandtner et al. fall within the range of the Husar estimates for all years except 1900 to 1925 and 1970 to 1980. Gschwandtner estimated higher emissions for the earlier years and lower emissions than Husar for 1970 to 1980.

Source Categories

The source categories included by Gschwandtner and Husar in their emission calculations are listed in Table 2. It is evident that the number of source categories considered by Gschwandtner greatly exceeds Husar's coverage. In particular, omission of the sulfur emissions from anthracite, distillate oil, wood, gasoline, and diesel fuel are to be noted. These missing categories would tend to result in lower values in Husar's sulfur emissions data.

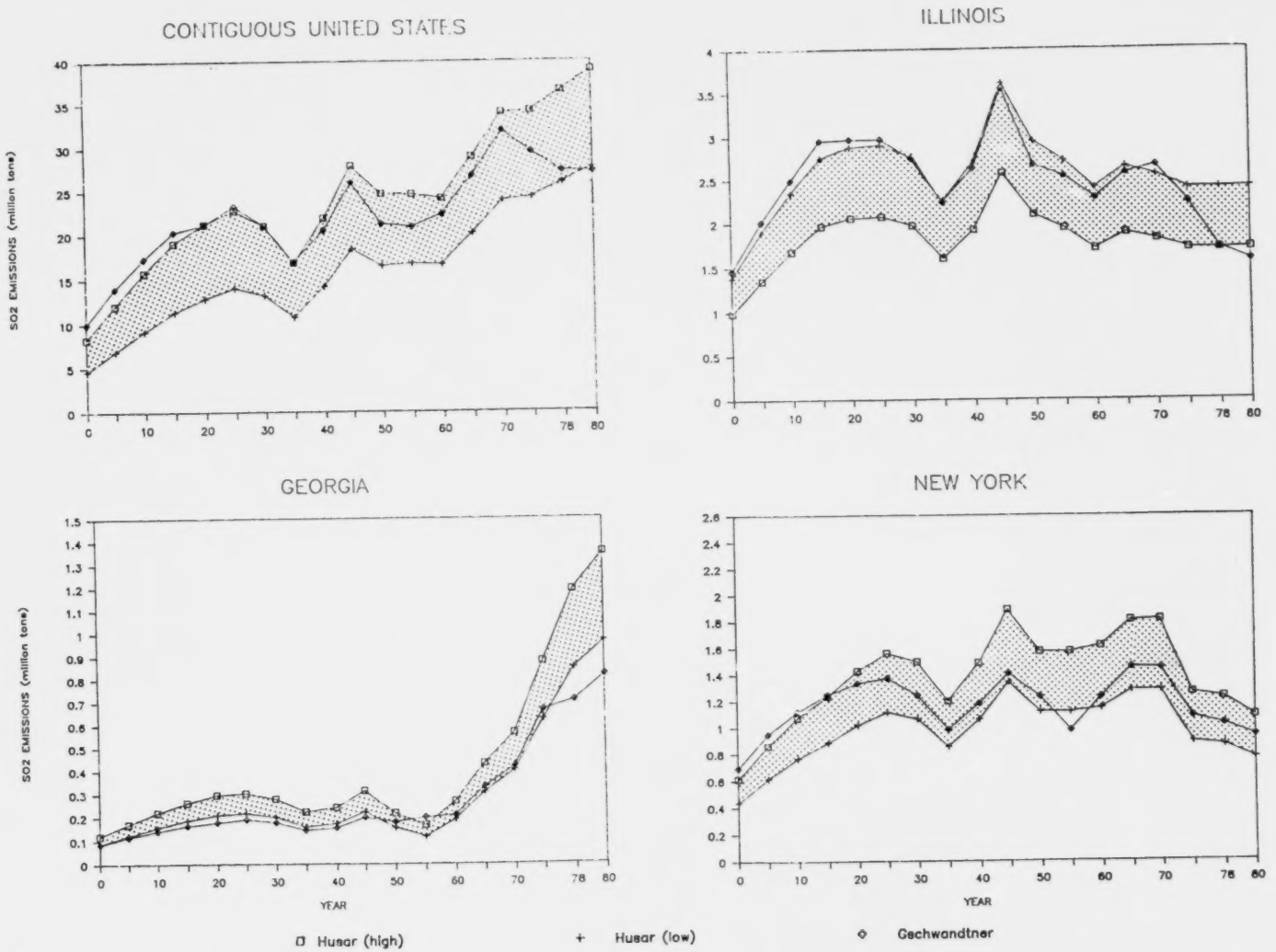

Figure 4. Comparison of SO_2 emission estimates of Husar and Gschwandtner, et al.

TABLE 2. COMPARISON OF SOURCE CATEGORIES FOR SO_2

FUEL TYPE	SOURCE CATEGORY	GSCHWANDTNER et. al.	HUSAR
Bituminous Coal:	Electric Utilities	x	x
	Industrial Boilers and Space Heaters	x	x
	Commercial and Residential Uses	x	x
	Steam Railroads	x	x
	Coke Plants	x	x
Anthracite Coal:	All Uses	x	
Residual Oil:	Electric Utilities	x	x
	Industrial Boilers and Space Heaters	x	x
	Commercial and Residential Uses	x	x
	Vessels	x	x
Distillate Oil:	Electric Utilities	x	
	Industrial Boilers and Space Heaters	x	
	Commercial and Residential Heating	x	
	Railroads	x	
	Vessels	x	
Natural Gas:	Electric Utilities	x	
	Industrial Boilers and Space Heaters	x	
	Pipeline Compression Station	x	
	Commercial and Residential Uses	x	
Wood:	Electric Utilities	x	
	Industrial Boilers and Space Heaters	x	
	Commercial Heating	x	
	Residential Wood Stoves and Fireplaces	x	
Gasoline and Diesel:	Highway Vehicles	x	
	Off-Highway Vehicles	x	
	Vessels	x	
Other:	Wildfires	x	a
	Cement Plants	x	
	Copper Smelters	x	x
	Lead Smelters	x	
	Zinc Smelters	x	x
	Pulp and Paper	x	
	Oil Refineries	x	
	Iron and Steel Mfg.	x	b
	Aluminum Mfg.	x	
	Secondary Lead	x	
	Aircraft	x	c

[a] Not considered by Husar to be an anthropogenic source. Wildfires are included by Gschwandtner because they are included in the U.S. EPA estimates of national emission trends.

[b] Included in bituminous coal category.

[c] Included in oil category.

The sulfur emissions for each state and year are calculated by the following equation:

S Emitted = Fuel Use * S Content * Emitted Fraction (1)

A comparison of the two data sets is best accomplished by comparing separately each of the three components: fuel use, sulfur content, and emitted fraction.

Fuel Use

Both Gschwandtner and Husar used fuel consumption data to calculate the emission rate. However, Gschwandtner assembled the fuel consumption data for different consuming sectors. In the case of coal consumption, for example, he obtained coal use and sulfur content data for the following sectors: electric utilities, industrial boilers, commercial-residential, railroads, coke plants, and cement plants. Husar only used total coal consumption and sulfur content for a given state regardless of the consuming sector. Hence, a comparison has to include the list of source categories and the consumption rate of specific fuels.

For example, in 1900, anthracite combustion accounted for about 9.6% of all SO_2 emissions from coal burning in the United States. By 1925, the percentage had decreased to 5% and subsequently has decreased further. Since anthracite and other source categories were not included in the Husar inventory, the Husar estimates are somewhat lower for the early years. From 1930 to 1970, the trends are similar, due to the relative decrease in the emissions of those source categories not included in the Husar inventory.

From 1970 to 1980, the trends of the two studies diverge. Gschwandtner shows a significant decrease beginning around 1970 while Husar shows an uninterrupted increase in total emissions. One reason for this difference is that Gschwandtner et al. accounted for the SO_2 removal by flue gas desulfurization (FGD) at power plants. By 1980, FGD systems accounted for about a 5 percent reduction in SO_2 emissions.

In order to investigate other differences, the total SO_2 emissions reported by Husar were adjusted to account for the differences in source categories and recent emission reductions. Figure 5 shows the total emissions reported by Husar plus the emissions of the omitted source categories, less the SO_2 removal by FGD systems estimated by Gschwandtner. The figure shows that the estimates of Gschwandtner are actually lower for certain states than the estimates of Husar when differences for source categories and FGD are accounted.

Bituminous Coal Consumption. Coal is the most significant sulfur emitting fuel. Figure 6 shows the bituminous coal consumption data used by the two investigators. As shown in

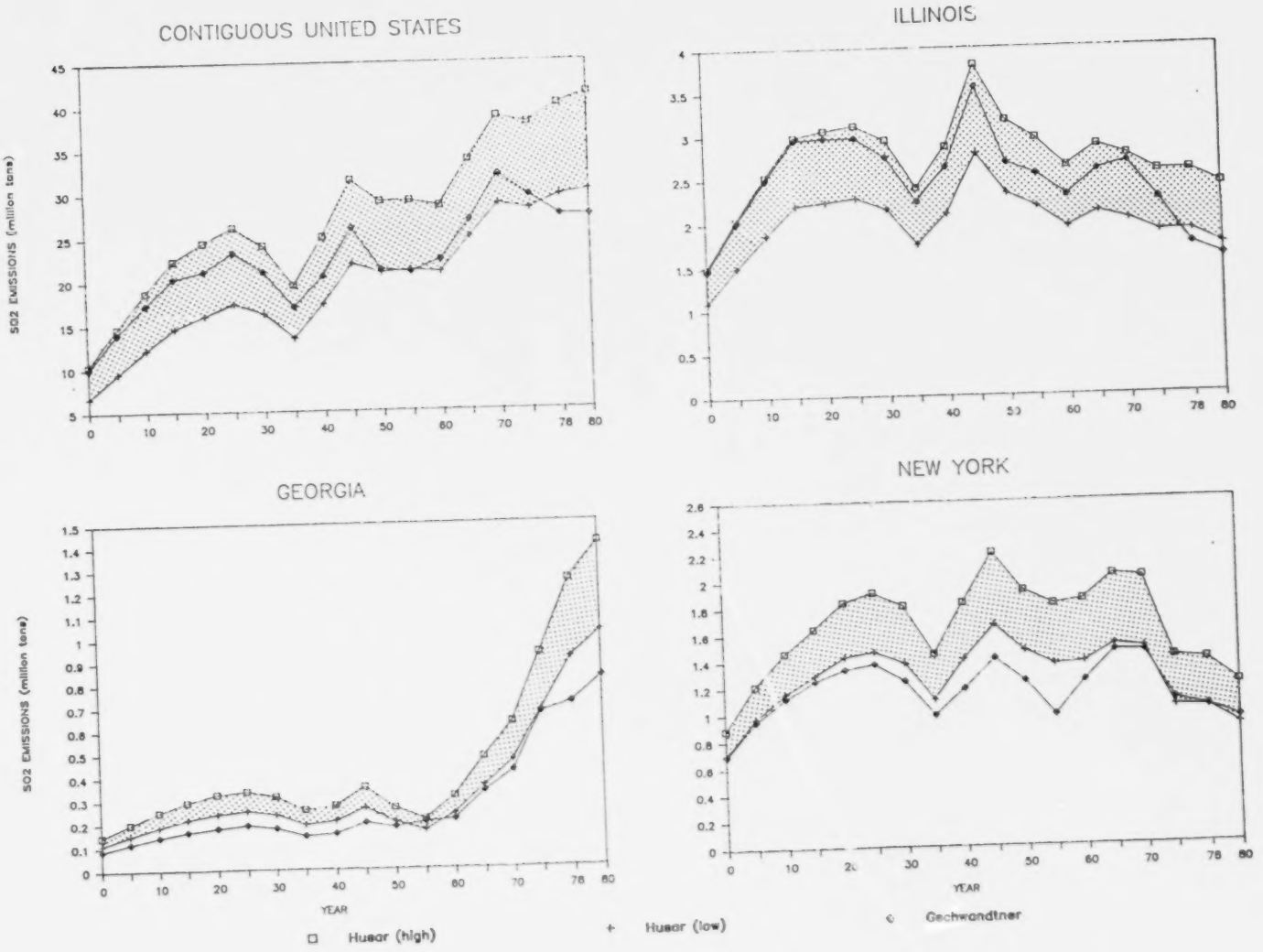

Figure 5. Comparison of SO_2 emissions after adjustment for source category accounting.

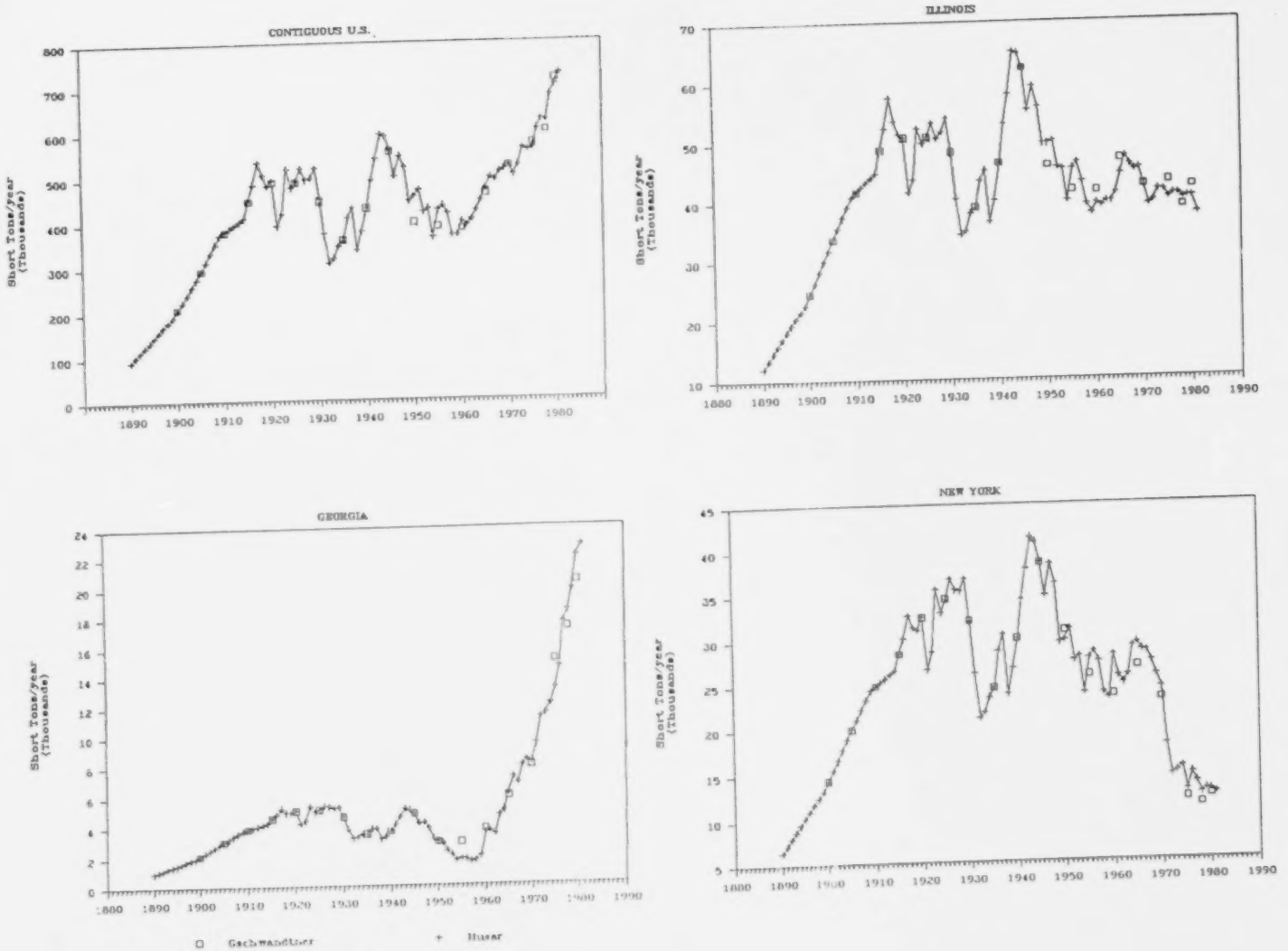

Figure 6. Comparison of historic coal consumption data.

Figure 6, Gschwandtner and Husar used identical data for 1900 to 1945. The coal consumption data were originally estimated by Husar using the data from the U.S. Bureau of Mines. These were adapted by Gschwandtner. However, some deviations are noted after 1945 when the investigators used different data sources and computational procedures. For the 1960-1981 period Husar used the consumption data reported by the DOE,[8] while Gschwandtner maintained the use of the Bureau of Census data.[9]

While the DOE data may be more reliable and more refined, the changeover to this data base may result in a slight discontinuity in the emissions trend. For this reason, Gschwandtner decided to continue using the Bureau of Mines data since 1950.

Figure 6 shows that the post-1945 coal consumption data for the contiguous U.S. are generally within about 5 percent except for 1950 and 1955 when coal consumption data deviate by up to 15 percent. The cause of this deviation is not clear. For individual states and years the consumption data are within about 10 percent. In general, it is fair to state that the bituminous coal consumption data are not a source of major deviation between the two inventories.

Sulfur Content

The determination of the sulfur content constitutes a major difficulty in estimating emissions. The sulfur content is the main source of uncertainty in the overall SO_2 emission estimate. It is also the main source of deviation between the Gschwandtner and Husar inventories and deserves more extended discussion. Relevant sets of sulfur content data are compared in Figures 7 and 8.

Figure 7 compares the trend in sulfur content of total coal reported by Husar and by Gschwandtner et al. for the contiguous United States. Husar reported two sets of sulfur values: national average values, and a range of values by state. The methods used to derive each set of values are explained later in this section. Gschwandtner reported average values by state. Figure 8 compares the sulfur content trend of coal for New York, Illinois, and Georgia. The sulfur content values of Husar are constant over time and are reported as a range, while the values of Gschwandtner vary from 1955 to 1980 and are constant for earlier years. When the Gschwandtner values are weighted according to the coal consumption by the different source categories, the overall sulfur value varies from year to year. The higher values used by Husar for New York and Georgia largely account for the higher estimated emissions for these states. Gschwandtner used the reported sulfur content of coal consumed by individual source categories. He used a variety of sources to obtain the best available sulfur content data.

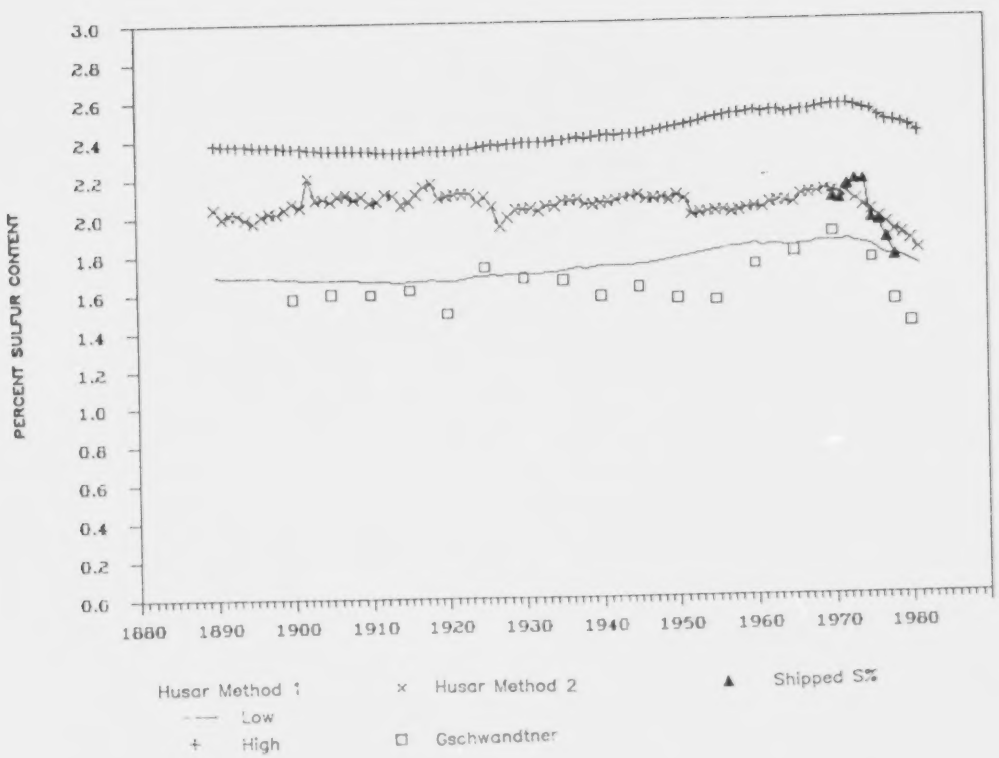

Figure 7. Average percent sulfur content values for the contiguous United States.

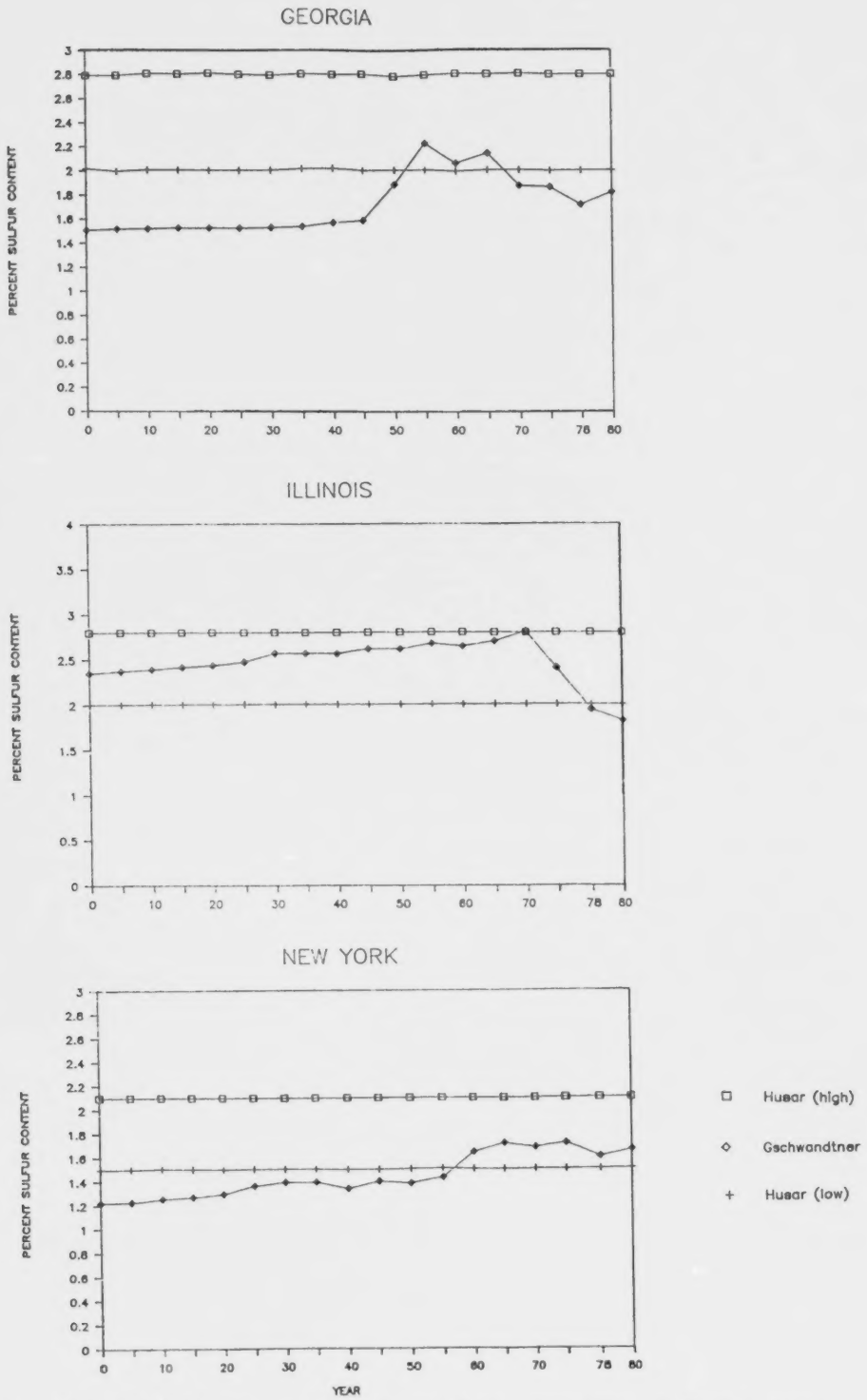

Figure 8. Comparison of percent sulfur content values for Georgia, Illinois, and New York.

Gschwandtner calculated the sulfur content of coal, as consumed, separately for 1955, 1965, 1970, 1975 and 1978 for individual source categories. The source categories and associated average sulfur values estimated by Gschwandtner for Illinois are shown in Table 3 as an example. The table also shows the weighted average sulfur value for all categories combined. These values are plotted in Figure 8. They include anthracite coal which generally has a lower sulfur content than bituminous coal. Gschwandtner used published data on coal properties and corresponding coal distribution data linking the coal mined to individual source categories on the state level. For 1955, the calculations involved analysis of coal sulfur content on a coal seam and mine field basis and calculating the flow of the sulfur to the end use category in each individual state. Since coal distribution data are not readily available for years before 1955, the 1955 data were used for 1900-1950 as well.

On the national scale Gschwandtner's calculations for the average coal sulfur content are shown as squares in Figure 7. This figure shows that over the 1900-1970 period the average sulfur content for all consumed coal (including anthracite) was about 1.6%. For 1970-1980 his calculations show a rather rapid decline from 1.6 to 1.4 percent in the national average coal sulfur content as a result of lower sulfur content reported in consumed coal.

Husar used exclusively the sulfur content of coal at the mines. He assumed that every mining district produces coal with a specific range of sulfur content that is determined by the geology of that region.[10] The details of his analysis are given in reference 2. The primary data source for coal sulfur content was a DOE report series (1970-1978) on the sulfur content of shipped coal.[11] These references were also used by Gschwandtner et al. Given the quantity of coal shipped and its sulfur content, the total tonnage of sulfur that left the mines as well as the average sulfur content could be calculated. The resulting sulfur content data for mine-shipped coal is shown as triangles in Figure 7. In 1970-1972 the sulfur content was about 2 percent By 1978 it declined to 1.75 percent. The relative shape of the shipped coal sulfur trend for 1970-1978 is similar to Gschwandtner's data. However, the absolute magnitude of the shipped coal sulfur is about 15 percent higher than Gschwandtner's consumed coal sulfur. The source of this discrepancy is not known to us. Considering the magnitude of the discrepancy it would deserve further investigation.

Unfortunately, detailed coal sulfur shipping data are only available for 9 years (1970-1978). In order to evaluate the historic trend of the U.S. coal sulfur content, Husar has applied two extrapolation procedures:

Method 1: In the first method it was assumed that the coal sulfur content for each coal producing district has remained

TABLE 3. SULFUR CONTENT BY SOURCE CATEGORY FOR ILLINOIS AS CALCULATED BY GSCHWANDTNER

YEAR	COMPOSITE SULFUR CONTENT (%)	REPORTED SULFUR CONTENT (%)						QUANTITY OF COAL CONSUMED (1000 SHORT TONS)					
		Electric Utilities	Industrial	Commercial Resident.	Anthracite	Railroads	Coke Plants	Electric Utilities	Industrial	Commercial Resident.	Anthracite	Railroads	Coke Plants
1900	2.35	3.25	2.10	2.73	0.80	3.24	1.55	1178	11107	5717	2149	4830	1761
1905	2.37	3.25	2.10	2.73	0.80	3.24	1.55	1952	14865	7996	2911	6722	2090
1910	2.39	3.25	2.10	2.73	0.80	3.24	1.55	2668	18004	10198	3140	8063	2647
1915	2.42	3.25	2.10	2.73	0.80	3.24	1.55	3560	20884	13122	3292	8595	2530
1920	2.44	3.25	2.10	2.73	0.80	3.24	1.55	4540	19881	13627	3321	9318	3433
1925	2.47	3.25	2.10	2.73	0.80	3.24	1.55	5900	17760	15544	2480	7726	3928
1930	2.57	3.25	2.10	2.73	0.80	3.24	1.55	5897	14183	17383	211	6643	4060
1935	2.57	3.25	2.10	2.73	0.80	3.24	1.55	4132	11818	14909	159	5198	2730
1940	2.57	3.25	2.10	2.73	0.80	3.24	1.55	6369	13548	16456	265	5816	4064
1945	2.62	3.25	2.10	2.73	0.80	3.24	1.55	9003	15845	24252	530	8651	4370
1950	2.62	3.25	2.10	2.73	0.80	3.24	1.55	11689	10834	14426	199	3732	5124
1955	2.67	3.25	2.10	2.73	0.80	3.24	1.55	17286	10126	9073	110	757	4323
1960	2.65	3.10	2.69	2.10	0.80	2.10	0.70	19218	12857	6368	92	91	2874
1965	2.70	3.10	2.69	2.10	0.80	2.10	0.70	25047	14168	3943	121	0	3607
1970	2.81	3.22	2.45	2.06	0.80	2.69	0.80	29453	6579	2590	107	0	3688
1975	2.41	2.58	2.45	1.68	0.80	2.45	0.60	34853	3494	507	34	0	3094
1978	1.94	1.99	2.21	1.78	0.80	2.21	0.88	33194	3165	210	67	0	2132
1980	1.82	1.84	2.21	1.78	0.80	2.21	0.88	36508	3391	154	63	0	2052

constant over the past century. The result of these calculations are shown as "X" in Figure 7. It shows a roughly constant sulfur content of 2 percent for the entire period 1890-1970. However, since 1970 there was a drop to below 1.8 percent. It arises from the strong increase of coal production in the western region which has low sulfur content. Here again, the trend is similar to Gschwandtner's estimates but displaced about 20 percent higher. The advantage of this calculation is that it yields the total sulfur mobilization, but it does not reveal the location where the sulfur is burned and emitted.

Method 2: The second method, which was used for estimating state level emissions, assumes that the source of coal for each state has remained constant over time. The results of these calculations are depicted as "Husar high" and "Husar low". In this case, the national average sulfur content is due to change of sulfur consumption in different states. The method uses coal consumption data and sulfur content derived from coal shipments in 1970-1978. The sulfur content is displayed as a range of low and high estimates. The procedures for establishing the uncertainty range are given in reference 2. The range of sulfur content is between 1.7 percent and 2.4 percent for most part of this century. It is evident that this method of calculation shows only a weak temporal trend. In particular, the strong decline in the 1970s is much less pronounced then in the above two calculations. As a result, his state by state trend data do not reflect adequately the reduction of average sulfur content since 1970.

A significant remaining question pertains to the discrepancy in the sulfur content data. The resolution of this issue is beyond the scope of this report.

Emitted Fraction

The third variable that is used in the calculation of the emission rate is emitted fraction. It is the fraction of sulfur in the fuel that is emitted to the atmosphere during combustion. The retained sulfur either remains as unburned ash sulfur or it is extracted in a flue gas desulfurization (FGD) process.

The emitted fractions used by Gschwandtner and Husar for bituminous coal are depicted in Figure 9. Their values differ in that Gschwandtner assumed that nearly all fuel sulfur is released to the atmosphere except for the fraction that is removed by flue gas desulfurization. Gschwandtner based the emitted fraction on emission factors reported by the U.S. EPA in Compilation of Air Pollutant Emission Factors, AP-42.[12] For bituminous coal combustion, the SO_2 emission factors reported in AP-42 are 39 lb

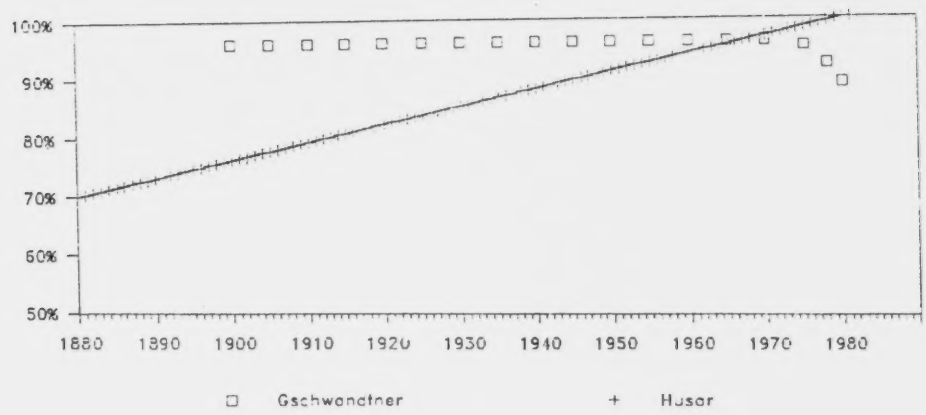

Figure 9. Percent of sulfur emitted by coal combustion.

S/ton coal for all firing configurations except underfeed stokers and handfired units, where the emission factor is lower. This value compares to an equivalent value of 40 lb S/ton coal used by Husar for 1980. For bituminous coal combustion, the sulfur retention is relatively small compared to that of other source categories and fuels. Hence, national average emission fraction values used by Gschwandtner are 97.5 percent until 1970 and decline to 90 percent by 1980 because of increased scrubbing.

Husar ignored scrubbers but assumed that only a fraction of the fuel sulfur is emitted to the atmosphere and the remainder is retained in the ash. He assumed that early coal furnaces were inefficient burners leaving substantial unburned fuel. He set the emission fraction to 70% in 1880 and 100% in 1980, and linearly interpolated in between. This factor tends to reduce the emission estimates over the early part of this century.

Husar's omission of FGD sulfur removal should clearly be remedied using available data. The omission of sulfur retention in old boilers should also be remedied in Gschwandtner's calculations. However, the magnitude of the retention in old furnaces is highly uncertain and deserves further study.

Sulfur Emission Rate from Coal Combustion

The sulfur emission rate for bituminous coal combustion is the product of the fuel consumption, coal sulfur content, and emitted fraction as discussed in the previous section. Figure 10 shows the SO_2 emission trends for coal combustion for Illinois, Georgia, and New York, which were selected as representative states. Figure 11 shows the SO_2 emission trend for the contiguous United States. The total U.S. coal sulfur emission trend shows that between 1900 and 1975 the Gschwandtner data are within the high and low range of Husar. However, around 1900, Gschwandtner data coincide with Husar's high estimate, while in 1950-1975 period his data coincide with Husar's low estimate. After 1975, Gschwandtner data are substantially below the Husar's low estimate. Gschwandtner data are plotted with anthracite (□) and without anthracite (+). Evidently, the main reason for the deviation around 1900 is Husar's assumption that only about 80% of the coal sulfur is emitted to the atmosphere. The deviation in the 1970s undoubtedly arises from Husar's assumption of a time invariant coal source for each state.

Figure 11 also shows the quantity of sulfur contained in coal shipment at mines. In the period 1970-1978, these shipments totaled about 24 million tons per year. This is about 20% higher than Gschwandtner's estimate of 20 million tons. This discrepancy arises primarily from the higher sulfur content of the produced and shipped coal, compared to the sulfur content of consumed coal.

Coal SO_2 emission trends for Georgia, Illinois, and New York are shown in Figure 10. For Georgia, Gschwandtner's data track

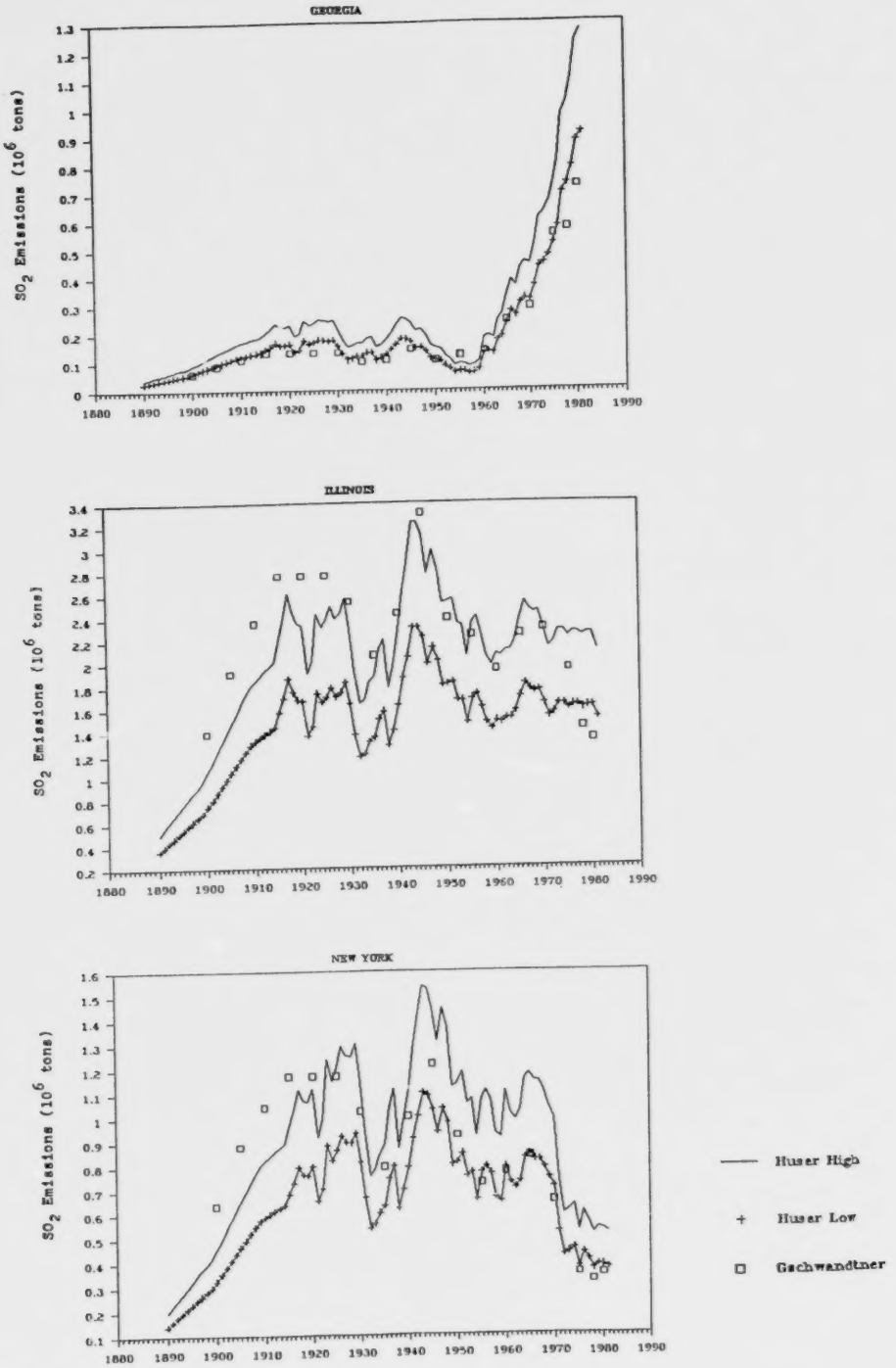

Figure 10. Comparison of SO_2 emissions from coal combustion in Georgia, Illinois, and New York.

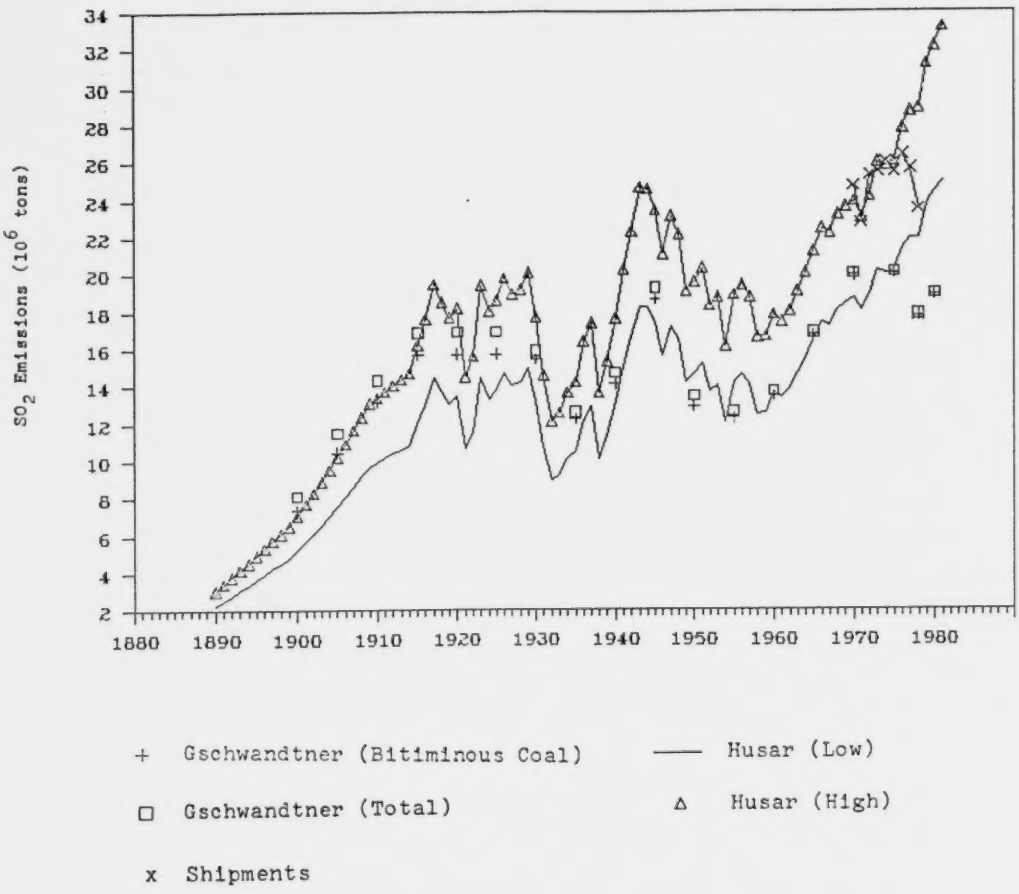

Figure 11. Comparison of SO_2 emissions from coal combustion in the contiguous United States.

Husar's low estimate for the entire time period 1900-1980.

For Illinois, discrepancies exist around 1900 as well as during 1978-1980. In the early years Gschwandtner's Illinois sulfur emission data are higher because he assumed that all sulfur is emitted to the atmosphere. The cause of the discrepancy in the late 1970s is the strong decline of average sulfur content due to the imported western coal which was ignored by Husar.

The reconstructed coal sulfur emission trend for New York shows an agreement between 1930 and 1980. Prior to 1930 the deviations arise for two reasons: Husar ignored anthracite, a significant fuel at that time, and Gschwandtner assumed that all sulfur is released to the atmosphere.

Discussion

Husar's method is based on coal production. Coal sulfur content is assumed to be a geological constant at the producing district. This facilitated the estimation of the uncertainty in coal sulfur content. Husar assumed that the distribution pattern of the coal from mine to end-use did not change over the study period.

Gschwandtner's method is based on coal consumption. The sulfur content of coal shipments varies with time to reflect a changing distribution pattern and changes in the sulfur content as mined. The change in sulfur content as mined from year to year is small, as is the net effect of coal cleaning and coal blending prior to consumption by a source category. Historic data on coal cleaning are not readily available. Coal cleaning is generally assumed to account for only a small fraction of the difference between produced sulfur and consumed sulfur.

The basic difference between the two methods is that one is based on coal production and the other on coal consumption. A direct comparison of sulfur content of coal produced in 1978 and the sulfur content of coal consumed by the various source categories shows a significant difference in respective values used. No explanation is readily apparent for why coal produced should have 20 percent higher sulfur content than coal consumed.

While the two methods are in agreement for comparable source categories for the early years, they show diverging trends for the recent years. Table 4 shows the net effect of differences in the input values of each inventory on the calculated SO_2 emissions from coal-fired electric utilities, industrial boilers, and commercial-residential furnaces combined. Illinois is selected to illustrate the difference because the state imports coal from both eastern and western states. The total uncontrolled emissions shown for Husar represent the median value estimates. On a percentage basis, the 1970 Gschwandtner emission estimate is 13.8 percent higher than Husar's, due to a 13.7

TABLE 4. COMPARISON OF ESTIMATED SO_2 EMISSIONS FOR ILLINOIS
(H = Husar, G = Gschwandtner)

	YEAR					
	1960		1970		1980	
	H	G	H	G	H	G
Coal Consumption (1000 short tons)	39,300	41,408	42,000	42,310	40,200	42,105
% Sulfur Content Emitted to Air[a]	2.18	2.14	2.18	2.48	2.18	1.79
Sulfur Emissions	1,001[b] 715[c]	886	1,074[b] 767[c]	1,049	1,023[b] 731[c]	605
Removal by FGD (1000 short tons)	--	0	--	0	--	148.1
Total Uncontrolled Emissions	858	886	921	1,049	875	754

	Percentage Differences[d]		
	1960	1970	1980
Coal Consumption	+ 5.4	+ 0.7	+ 4.7
% Sulfur Content	- 1.8	+13.7	-17.9
Total Uncontrolled Emissions	+ 3.2	+13.8	-14.1

[a] Calculated by dividing total sulfur emissions by total coal consumption.

[b] high estimated value

[c] low estimated value

[d] calculated as $\frac{\text{Gschwandtner - Husar}}{\text{Husar}} \times 100$

percent higher sulfur value for this particular year, and a 0.7 percent higher coal consumption value. However, for 1960, the Gschwandtner emission estimate is 14.1 percent lower, largely as a result of a sulfur value that is 17.9 percent lower than Husar's median estimate. Husar's sulfur range, as explained earlier, is constant over time.

Based on this comparison effort we recommend that the Gschwandtner et al. inventory be used by NAPAP. It has a more complete source characterization and better reflects the recent changes of average sulfur concentration. Also it is currently available to researchers through the NTIS system. Husar's research inventory revealed that an independent calculation of sulfur content of the mined and shipped coal is about 20 percent higher than the sulfur content of the consumed coal. Hence, the absolute magnitude of coal sulfur emissions calculated from consumption data may be too low by up to 20 percent. However, this discrepancy could not be resolved in the framework of this study.

COMPARISON OF NO_x EMISSIONS

Figure 12 compares the total NO_x emissions estimated by Husar and Gschwandtner. Both estimates show a similar trend for the United States and for the individual states. Again the emission estimates of Husar are generally lower for the early years and higher for the recent years.

Source Categories

Table 5 lists the source categories not included in the Husar inventory that explain the difference in the early years. As in the SO_2 inventory, these categories are not considered by Husar to be significant, and wildfires are not considered by Husar to belong in an anthropogenic emission inventory.

Emission Factors

There is substantial uncertainty in historic NO_x emission factors. Both Husar and Gschwandtner recognized this uncertainty and approached this problem in slightly different ways.

Husar used time-varying emission factors to reflect the change in emissions as a result of changes in combustion technology. In the absence of any historic data that would quantify the rate of change, Husar developed factors that vary linearly over time and which are lower for the earlier years to reflect generally lower temperatures of combustion. Husar assumed a trend in the emission factors for four fuel categories: coal, gasoline, fuel oil, and natural gas combustion. In the case of coal combustion and gasoline, the emission factors varied with time. For fuel oil and natural gas, the factors were held constant over time. For 1980, the starting point for

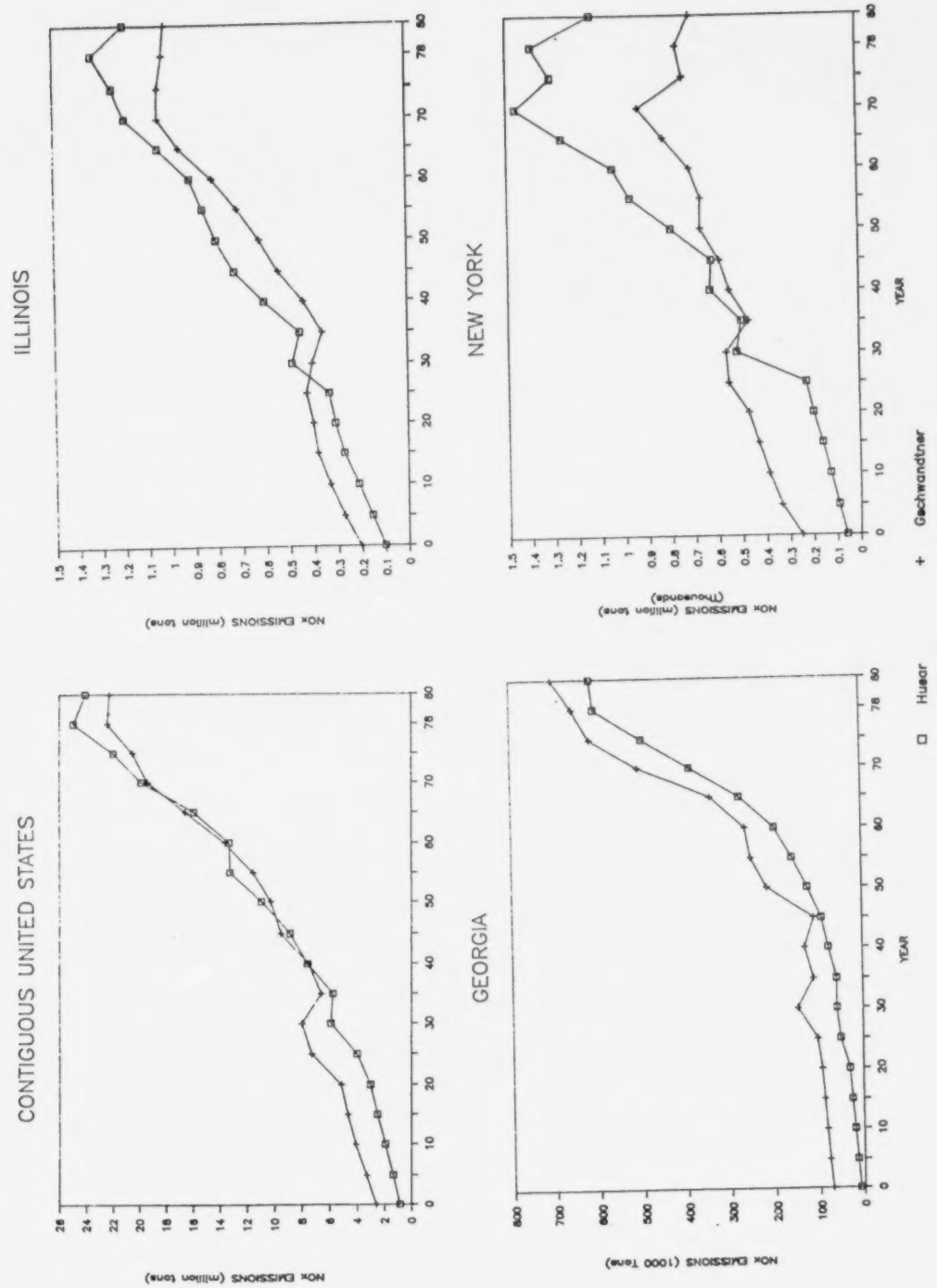

Figure 12. Comparison of NO_x emission estimates.

TABLE 5. SOURCE CATEGORIES AND NO_X EMISSIONS NOT INCLUDED BY HUSAR

Source Category	Estimated National NO_X Emissions (million tons) 1900	1910	1920	1930
Anthracite Coal - All Uses	0.2	0.6	0.6	0.4
Wood - All Uses	0.1	0.1	0.1	0.1
Wildfires	0.8	0.4	0.4	0.4
Various Misc. Other Sources	0.1	0.1	0.1	0.1
Total	1.2	1.2	1.1	1.0
Percent of Total Emissions	50%	32%	23%	14%

backtracking the factors, the values of the emission factors were derived from the estimates of Gschwandtner et al.

Gschwandtner et al. used a more detailed approach. The emission factors for individual types of boilers and processes were obtained from AP-42.[12] These factors were weighted to represent each source category as defined by Gschwandtner et al. While the AP-42 emission factors were held constant over time, the relative weighting of each emission factor did change over time and was taken into account by the source category activity data. As a result, the emission factors for aggregated categories such as coal, gasoline, fuel oil, and natural gas combustion vary over time.

Figure 13 compares the composite emission factors of Husar and Gschwandtner et al. for these four fuel types. The figure shows that the emission factors used by Husar and the factors derived from the Gschwandtner data are comparable.

In the case of coal combustion, differences exist because Husar did not include anthracite coal, a major fuel in the earlier years, and assumed a linear trend. For gasoline combustion, the trends are similar, but small differences exist because Husar did not include diesel fuel in determining highway vehicle emissions. For fuel oil combustion, the emission factors differ significantly because Husar did not include distillate oil which historically contributed about the same amount of NO_x emissions as residual oil on the national level. Husar assumed a constant emission factor for residual oil.

For natural gas combustion, the emission factors are considerably different in the recent years due to a difference in the emission factor for 1980. Husar used a value of 0.44 tons $NO_x/10^6$ cu. ft. natural gas, compared to Gschwandtner's value of 0.18 tons $NO_x/10^6$ cu. ft. Gschwandtner's factor is based on the weighted average emission factor shown in Table 6.

The differences in the emission factors help explain the differences in the NO_x emissions shown in Figure 3. In New York, where the use of natural gas is more predominant than in Illinois, for example, Husar's method produces higher emission estimates due to a higher assumed emission factor for the natural gas combustion category. For all categories combined, Husar produces higher estimates of NO_x emissions as a result of generally higher assumed emission factors. If the emission factors used by Husar had included the same subcategories as Gschwandtner, the values for 1980, at least, would have been identical.

Both methods lack the actual historic emission factors specific to early combustion technology. Such information is not currently available, and reliance must be placed on modern era emission factors based on recent source emission tests. Despite this limitation, the two approaches are similar and the estimates

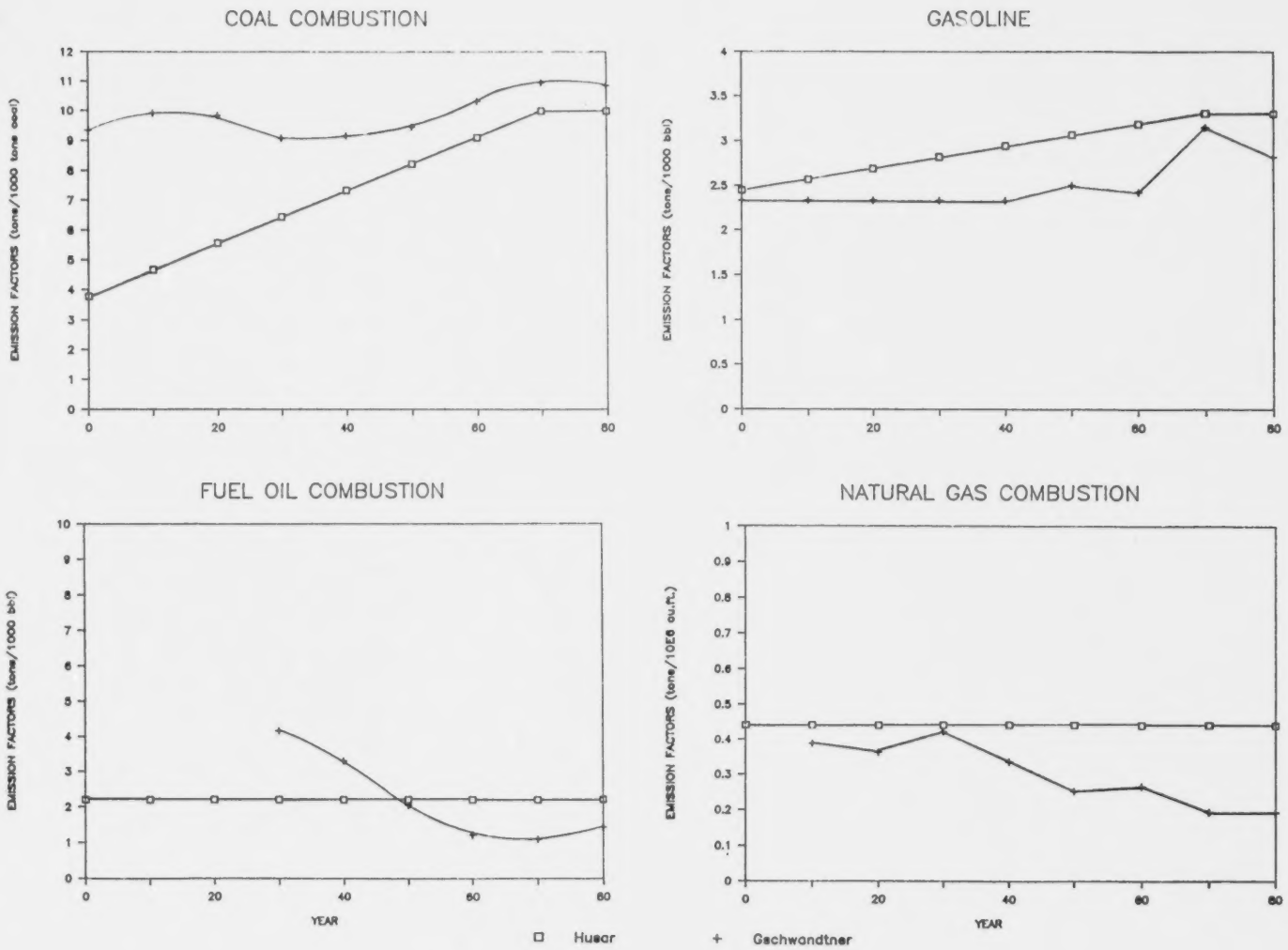

Figure 13. Comparison of NO_x emission factors.

TABLE 6. NO_X EMISSION FACTORS FOR NATURAL GAS COMBUSTION (1980 ONLY)

Source Category	Emission Factor[a] (tons/10^6 cu. ft.)	1980 U.S. Consumption (10^6 cu. ft.)
Electric Utilities	0.245	3,835,376
Industrial Boilers	0.07	7,101,891
Pipelines	1.25	1,630,041
Commercial - Residential	0.05	8,390,588
Weighted Average EF:	0.186	
Total:		20,957,896

[a] Derived from AP-42

are nearly identical when adjusted for differences in source category accounting.

SUMMARY AND CONCLUSION

The two methods yield similar results. When the methods are compared for similar source categories, the results are essentially the same.

For SO_2, the greatest difference occurs in the estimation of fuel sulfur content values of consumed coal. When the methods are compared in detail, the basic difference is attributable to differences between the reported quantity of coal sulfur produced and the quantity consumed. The resolution of this difference, which results in different SO_2 emission trends, would require further investigation of the reported data.

Other differences are:

1. Anthracite coal, distillate oil, and wood were not included in the Husar inventory.

2. Forest fires, lead smelters, pulp and paper, aluminum manufacturing, and other miscellaneous industrial sources were included by Gschwandtner et al.

3. Gschwandtner assumed that all the coal S is emitted while Husar assumed that in 1880 only 70% of coal S is emitted.

By including the omitted subcategories in the Husar estimates, the results become closer. However, the basic issue of uncertainty is not addressed by adding extra categories. The uncertainty and the reliability of the historic emissions will become clearer when the sulfur mobilization is studied in greater detail. For example, coal distribution data are available for 1917 which neither researcher was able to incorporate due to budget limitations.

There is no compelling reason for either researcher to change his respective estimates. As a result of this study, the differences are better understood and attributable to different methods and approaches. The inventory produced by Gschwandtner et al. for NAPAP is considered to be complete. It is recommended that these estimates be used in studies of long-term changes in emissions by source category and changes in observed environmental damage. For studying the trend in total national emissions, either the Gschwandtner estimates or the EPA emission trends from 1940 to 1985 may be used. The EPA trends estimates are reviewed and compared to the Gschwandtner estimates in Section 3 of this report. As before, the research/exploratory inventory of Husar can be used as a framework for testing alternative data sources and computational procedures.

SECTION 3

COMPARISON TO OTHER ESTIMATES

This section describes other emission estimates that can be compared to the estimates of Gschwandtner et al. for certain years. These other emission estimates include the following.

- National Emission Trends, 1940-1985[3]
- National Electric Utility Emission Estimates, 1975-1983[4]
- Monthly Emissions, 1975-1984[5]

The comparison of results is described for each of these other estimates in terms of objectives and methodology.

NATIONAL TRENDS, 1940-1985

The national emission trends reported by the U.S. EPA[3] are compatible with the estimates of Gschwandtner on the national level. It is important to understand that the primary purpose of the EPA estimates is to establish the trend in emissions. The Operations and Maintenance Section of the National Air Data Branch calculates national emissions each year for the previous year, and applies the same calculation procedure to all earlier years. The updating procedure generally takes place in late October and early November, when all the necessary publications and references used in the procedure are available.

EPA Calculation Procedure

Annual national emissions are calculated individually for hundreds of source categories. Collectively, these source categories account for all anthropogenic emissions. The emission estimates are not made at actual source locations. Instead, they are based on a "top down" approach. First, total nationwide uncontrolled emissions are estimated for individual major source categories such as electric utilities and iron and steel mills. The amount of emissions controlled is estimated. The difference between the two represents the actual emissions. For some source categories, such as highway vehicles, estimates of actual emissions are computed directly without performing an initial calculation of uncontrolled emissions.

The EPA procedure is outlined in Figure 14. For each pollutant, uncontrolled emissions are estimated from annual national fuel consumption figures or some other appropriate indicator of the overall activity of each source category. In the case of particulate and SO_2, average fuel property values such as ash and sulfur content are included in the estimation procedure. National average emission factors are calculated for each pollutant by source category. In addition, a national average emission control efficiency is estimated for particulate and SO_2 emission sources usually. These data are entered into a computer spreadsheet that computes the estimated actual emissions

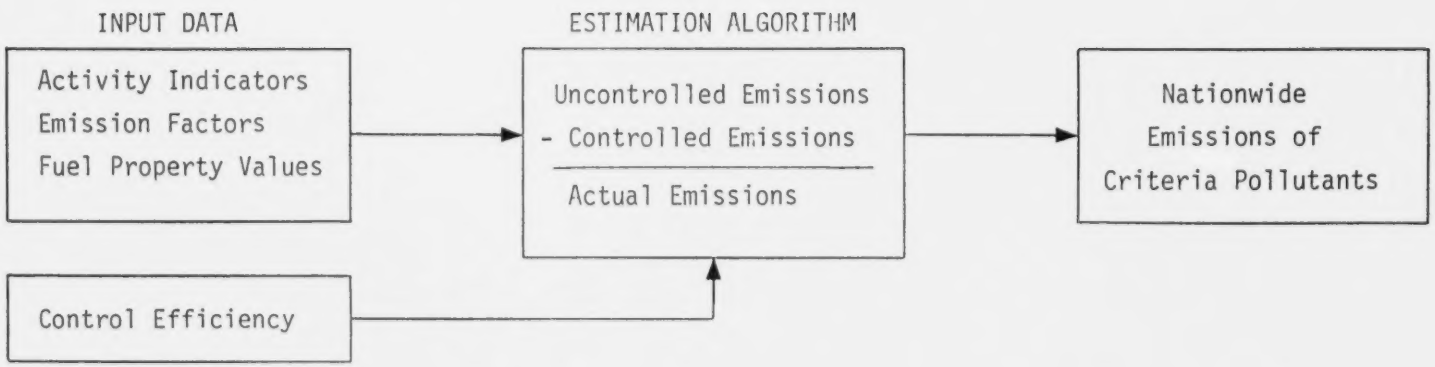

Figure 14. Overview of the EPA procedure for estimating nationwide emissions.

by pollutant and by source category. The individual source category emissions are added to yield an estimate of total national emissions.

Since the estimates are based on input data which may be updated or revised from time to time, the estimating procedure may change. For example, the emission factors published in AP-42 may be revised. If this occurs, it is necessary to revise all previous estimates where the original emission factor was used. This requires updating the spreadsheet for all previous years. Similarly, fuel consumption data may change from one year to the next as the statistics produced by various trade associations and governmental agencies are revised. Therefore, the EPA revises previous annual estimates when revised data are available.

Comparison with Gschwandtner et al.

As described by Gschwandtner et al.[1], the calculation of national emissions is, in many ways, easier than calculating state level emissions. The state level estimates required making many assumptions and additional calculations that were not necessary on the national level. The basic calculation procedures are also different as a result of having to calculate emissions for 48 states and the District of Columbia individually. Numerical rounding alone associated with adding 49 subtotals alone can account for up to 2.5 percent of the difference in total emissions.[1]

In addition, the EPA estimates the emissions for all states, territories and possessions of the United States combined. The estimates of Gschwandtner include only the contiguous United States.

Another difference between the two estimates involves the definition of source categories. The EPA estimates involve over 200 individual source categories. The estimates of Gschwandtner include only 27 source categories which collectively represent all anthropogenic emissions. The reduction in the number of source categories was necessary in order to simplify the calculation procedure given the allotted budget. As a result, direct comparison of emissions on a source category basis requires an understanding of the definition of each source category. For example, pulp and paper plants, petroleum refineries, and other industrial processes are contained in the Gschwandtner et al. study under the Miscellaneous category and were calculated collectively. In the EPA data base, these sources are contained in the Industrial Processes category and are calculated individually.

Summary of Differences

Table 7 reports the percentage difference between the total emissions reported by each methodology. The table shows the difference as it was in 1985, when the Gschwandtner estimates

TABLE 7. DIFFERENCE BETWEEN EPA TRENDS AND THE HISTORIC SO_2 AND NO_X EMISSIONS

Year of Calculation	Percentage Difference in Total SO_2 Emissions Year						
	1940	1950	1960	1970	1975	1978	1980
1985	-2.8	+5.7	-0.5	-2.0	-4.2	-0.5	-5.8
Present	-2.8	+5.9	+0.3	-2.1	-4.0	-0.9	-5.8

Year of Calculation	Percentage Difference in Total NO_X Emissions Year						
	1940	1950	1960	1970	1975	1978	1980
1985	-2.3	-1.6	+2.8	+2.8	+3.1	+4.1	+2.5
Present	-1.4	0	+3.3	+2.9	+3.6	+4.4	+0.8

were published, and at the present time. The table shows changes in the percentage differences as a result of procedural and informational changes associates with the EPA estimates, as explained earlier. It is expected that in future years, as some emission factors and data change further and since the historic estimates of Gschwandtner remain constant the differences will again change.

On the national level, the EPA emission estimates are considered more reliable than the estimates of Gschwandtner since the EPA estimates are based on more detailed source categories. The Gschwandtner estimates are based on generally larger and more manageable source categories, fewer in number than in the EPA inventory. Also, the estimates of Gschwandtner required making more assumptions regarding the grouping of source categories in order to reduce the calculation procedure for each state. Each assumptions introduces additional possible error and differences on the national level when state-level emissions are aggregated.

Adjustment of Historic Emission Estimates

In order to eliminate errors introduced by additional assumptions and calculation procedures in the Gschwandtner inventory, the historic state level estimates have been adjusted. First, the historic emissions for Alaska, Hawaii, and territories of the United States were estimated. These estimates were then subtracted from the EPA national estimates so that only the contiguous United States would be represented.

The total emissions for major source categories such as electric utilities, industrial, commercial-residential, highway vehicles, and other sources as reported by each study were compared. The ratio of the total emissions for each category was used to adjust the historic emissions reported by Gschwandtner et al. The calculation procedure is described as follows:

$$\text{Adjusted Emissions}_{ij} = \text{Original Emissions}_{jj} \times \frac{\text{EPA Contiguous}_j}{\text{Original Emissions}_j} \qquad (2)$$

where i = State

j = year (1940, 1950, 1960, 1970, 1975, 1978, 1980)

EPA Contiguous = National EPA emissions estimates minus the estimated emissions of Alaska, Hawaii and territories.

Original Emissions = Emissions of the contiguous United States reported by Gschwandtner et al.

The adjusted state-level SO_2 emissions are presented in Appendix A. The adjusted NO_x emissions are presented in Appendix B. As a result of this adjustment, the numbers are identical, but they can be expected to be different in the future.

Considerable confusion has resulted in NAPAP due to the small differences between the EPA national trends estimates and Gschwandtner estimates as originally reported. It is important for the user of the historic emission estimates to understand their primary purpose. For example, for determining the total national emission trend, the U.S. EPA estimates should be used. For determining state emission trends, the Gschwandtner estimates should be used. If the aggregated state trends are compared to the national emission trends, the revised state level emissions estimates contained in Appendix A and B should be used.

NATIONAL ELECTRIC UTILITY EMISSION ESTIMATES, 1975-1983

Since the estimates of the EPA and Gschwandtner et al. are now identical, the next step is to investigate differences between electric utility emission estimates[4] and the EPA trends. The Pechan estimates are considerably more detailed than the EPA estimates. Electric utility emissions are estimated at the boiler level, while the EPA calculates emissions on the plant level. The purpose of the Pechan estimates is to present highly accurate estimates of electric utility emissions each year. The primary purpose of the EPA estimates is to present a consistent indication of the emission trend. These differing primary objectives make it difficult to produce identical results each year, especially when the electric utility estimates may include new and detailed information each year.

The EPA requires the ability to update the national emission trends estimates each year. Therefore, a consistent and practical methodology must be used for all years. It is possible to change the EPA calculation procedures so that the results are identical for a particular year. However, the application of the revised procedure to other years may not necessarily produce the same results as the Pechan estimates. In the case of SO_2, the reasons involve detailed information on boiler operations, coal properties, and other factors which are beyond the level of detail of the EPA national estimates. Similarly, other factors affect the outcome of the NO_x emission estimates.

In 1987, when the EPA emission trends are updated and emissions are estimated for the year 1986, an attempt will be made to produce results identical to the Pechan electric utility estimates. The calculation procedure used in the past may be modified and the same procedure may be applied to all earlier years in order to preserve consistency in methodology. In 1988, when the EPA emission trends are again updated, the same procedure may not necessarily produce results identical to the Pechan estimates as it did in 1987. Therefore, the procedure will again need to be reviewed and modified accordingly, and applied to all earlier years.

MONTHLY EMISSIONS, 1975-1984

The monthly emissions of SO_2 and NO_x for the 48 contiguous states developed by Knudson[5] are based on the U.S. EPA national emission trends estimates and the 1980 NAPAP emission inventory. State emission totals were obtained for two main categories: electric utilities, and non-utility sources.

The SO_2 emission estimates for electric utilities were taken from Pechan[4] for 1975 to 1983. For 1984 and 1985, the SO_2 emissions were calculated by Knudson[5] using a methodology consistent with the Pechan method. The NO_x emission estimates for electric utilities were calculated using plant activity data obtained from the U.S. Department of Energy Form 759 and plant level NO_x emission factors developed from 1980 Pechan data which included the Argonne file on boiler firing types.

Annual non-utility emissions were obtained from the U.S. EPA[3] and the 1980 NAPAP state emission totals. The monthly emissions were estimated using various activity data and statistics to represent the activity of each source category.

Since the monthly emissions estimates are based on two data bases (electric utility emissions estimates and the U.S. EPA) that report the same total estimates of Gschwandtner et al. after adjustment of the Gschwandtner estimates, the two data sets are compatible. The total historic SO_2 and NO_x emissions of Gschwandtner et al. are identical to the EPA national trends estimates excluding states and territories outside the contiguous United States. The Pechan emission estimates and the national emission trends estimates are also in agreement to the extent described previously. Therefore, the data bases are identical on the national level for comparable study years.

Differences do exist on the state level since Knudson used 1980 NAPAP state emission totals as the basis for apportioning the national emissions to the state level. The historic SO_2 and NO_x emission estimates of Gschwandtner et al. were derived for many individual source categories on the state level and were added to yield state total emissions. The method used by Knudson produces consistent results and is compatible with other NAPAP estimates. However, the state-level estimates derived by this top-down approach will not be identical to the bottom-up approach of Gschwandtner et al. The differences that exist are small, generally less than 5 percent for identical source categories on the state level.

SECTION 4

APPROACH TO UNCERTAINTY ANALYSIS

BACKGROUND AND METHODOLOGY

NAPAP has sponsored several projects to develop and test approaches to quantifying the uncertainty of an emissions inventory. The methodology developed by Brookhaven National Laboratory[13] and tested on the 1980 NAPAP Emissions Inventory[14] has been subject to NAPAP's extensive review and analysis procedures. Although doubts about the validity of the method have yet to be resolved, lacking any other acceptable means to quantify the uncertainty of these historic SO_2 and NO_x emissions inventories, the NAPAP methodology was studied for possible adaptation to historic emission estimates. This methodology is documented in detail in references 13 and 14.

The NAPAP methodology defines the uncertainty of an emissions estimate in terms of the uncertainty of the individual factors required in the emissions calculation. In the case of SO_2, these factors are fuel use, fuel sulfur content, and the emission factor. In the case of NO_x, these factors are fuel use and the emission factor. The uncertainty in the SO_2 emissions estimation can be calculated as follows:

$$SO_2\ p^2 = (1/165^2)*((1+165^2 p_{ef}^2)*(1+165^2 p_a^2)*(1+165^2 p_s^2)-1) \quad (3)$$

where

p = Percent error

p_{ef} = Percent error in emission factor

p_a = Percent error in activity

P_s = Percent error in sulfur content

The uncertainty in the NO_x emissions estimation can be calculated as follows.

$$NO_x\ p^2 = (1/165^2)*((1+165^2 p_{ef}^2)*(1+165^2 p_a^2)-1) \quad (4)$$

These calculations were performed at the lowest level of disaggregation that the inventory would support. In the Gschwandtner historic SO_2 and NO_x inventories, activity and emission factor data have been estimated at the subcategory level.

The overall uncertainty of all source categories combined is given by:

$$p_T^2 = \sum_{i=1}^{N} p_i^2 E_i^2 \; / \; E_T^2 \qquad (5)$$

where

P_T = Total uncertainty

p_i = Uncertainty for subcategory i

E_i = Emissions for subcategory i

E_T = Total emissions

The difficulty in applying this methodology to an emissions inventory arises due to the lack of test data on which to base the uncertainty estimates of the emission factor, activity, and sulfur content data. In the case of historic emission estimates, historic test data are presently nonexistent, and considerable judgment and assumptions must be applied to develop emission factors and activity levels from which historic emissions may be estimated.

In the absence of any better information at this time on which to base these estimates, the values selected for use in the 1980 NAPAP Emissions Inventory uncertainty effort were used as a starting point in this analysis. Since they are the only uncertainty values published to date, they serve as a benchmark against which other uncertainty estimates developed using a consistent methodology can be compared.

It should be noted that the uncertainty values derived for the NAPAP 1980 base year inventory were to be used as illustrative examples only. Therefore, the uncertainty estimates presented in this section do not represent actual uncertainty. Instead, the estimates are shown to illustrate a possible approach.

It is recognized that the emission factor and activity uncertainty values assigned in the 1980 NAPAP Emissions Inventory uncertainty effort are intended to be applied at the source classification code (SCC) level. The subcategories defined in the current historical work can be considered aggregations of these SCC-level data. Because the uncertainty of an emissions inventory decreases with increasing levels of aggregation, the application of SCC level uncertainty values to more aggregate subcategories can be considered a conservative assumption in analyzing uncertainties of the historic emissions inventory.

UNCERTAINTY ESTIMATION PROCEDURE

Emission Factor Uncertainty

First, the 1980 NAPAP uncertainty values of 31 percent for transportation sources and 25 percent for all other sources were assigned to the 1980 historic inventory data for illustrative purposes.

These values were accepted by NAPAP as illustrative examples of SCC level uncertainty. Since NAPAP has not provided any estimates of the uncertainty associated with larger source categories, such as those used in the historic inventory, these values are used.

The 1980 uncertainty values were scaled to represent emission factor uncertainty in the earlier years. Gschwandtner assumed that uncertainty for emission factors increased 100 percent from 1980 to 1940 for both SO_2 and NO_x. From 1940 to 1900, the uncertainty of the SO_2 emission factors was assumed to increased another 14 percent, and for NO_x, 26 percent. The assumed emission factor uncertainty values are presented in Appendix C.

Activity Uncertainty

A similar procedure was applied to estimate the uncertainty in the fuel use for each year and source category. The 1980 NAPAP uncertainty values of 15 percent for point sources and 25 percent for area sources were assigned to the 1980 historical data in this illustrative example.

Because activity data are not always available for every source category and year, emissions were sometimes estimated based on derived activity data such as surrogate indicators or linear interpolation. Based on professional judgment and knowledge of the activity and surrogate data, the relative uncertainty of each source category for each year was assigned according to the following criteria:

Method of Derivation	Scaling
Reported value	1
Apportionment based on a surrogate indicator	2
Linear interpolation	4
Assumption	5
Best guess	10

The 1980 uncertainty values were scaled based on the assigned relative uncertainty in activity data to arrive at the activity uncertainty table presented in Appendix C.

Sulfur Content Uncertainty

The uncertainty of fuel sulfur content is the major component in the uncertainty of historic SO_2 emissions. The estimates of historic sulfur content values derived by Gschwandtner et al.[1] and Husar[2] were used to provide preliminary indications of uncertainty. The uncertainty was estimated as follows.

$$P_S = \frac{\text{Husar (high)} - \text{Husar (low)}}{\text{Gschwandtner}} \times 100 \qquad (6)$$

where

Husar (high) = Upper limit of national average sulfur content range

Husar (low) = Lower limit of range

Gschwandtner = National average value reported by Gschwandtner et al.

This equation calculates the percentage spread in the reported values. It is important to recognize that further research is needed in order to determine the actual sulfur content uncertainty. As explained in Section 2, the Husar and Gschwandtner methods yield significantly different results. The uncertainty calculated by Equation 5 in this exercise should be regarded as purely illustrative.

Source Category/Year Uncertainty

The uncertainty of each of the parameters for each source category and year were combined according to the NAPAP uncertainty methodology defined by Equations 2 and 3. The resulting uncertainty values for each source category and year are presented in Appendix C.

Emissions Inventory Uncertainty

Using the national historical SO_2 and NO_x emission estimates of Gschwandtner et al. and the yearly source category uncertainty values determined above as input data, Equation 4 was used to determine the uncertainty of the historic total SO_2 and NO_x emissions for the contiguous United States and for major source categories. The results are presented in Table 8 and the estimated overall uncertainty is plotted in Figures 14 and 15.

TABLE 8. HISTORIC SO2 AND NOx EMISSIONS UNCERTAINTY

SO2 UNCERTAINTY	Uncertainty (percent)																
SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980
STATIONARY SOURCE FUEL COMBUSTION	66	65	65	65	67	61	62	61	61	58	54	53	48	45	41	43	50
TRANSPORTATION	78	77	77	75	77	64	62	62	64	61	60	44	32	31	29	29	32
MISCELLANEOUS	51	49	48	48	46	46	44	43	49	44	30	27	25	22	20	21	23
OVERALL SO2 UNCERTAINTY	43	43	43	42	45	40	41	40	40	39	34	36	35	33	31	35	41

NOx UNCERTAINTY	Uncertainty (percent)																
SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980
STATIONARY SOURCE FUEL COMBUSTION	45	45	42	42	41	38	36	35	33	31	28	27	24	22	18	18	19
TRANSPORTATION	82	80	77	70	65	38	39	41	43	36	41	41	39	36	34	34	34
MISCELLANEOUS	80	76	73	71	70	66	42	42	40	43	44	43	40	38	36	35	32
OVERALL NOx UNCERTAINTY	38	36	33	32	31	25	23	23	23	21	21	21	19	18	16	18	18

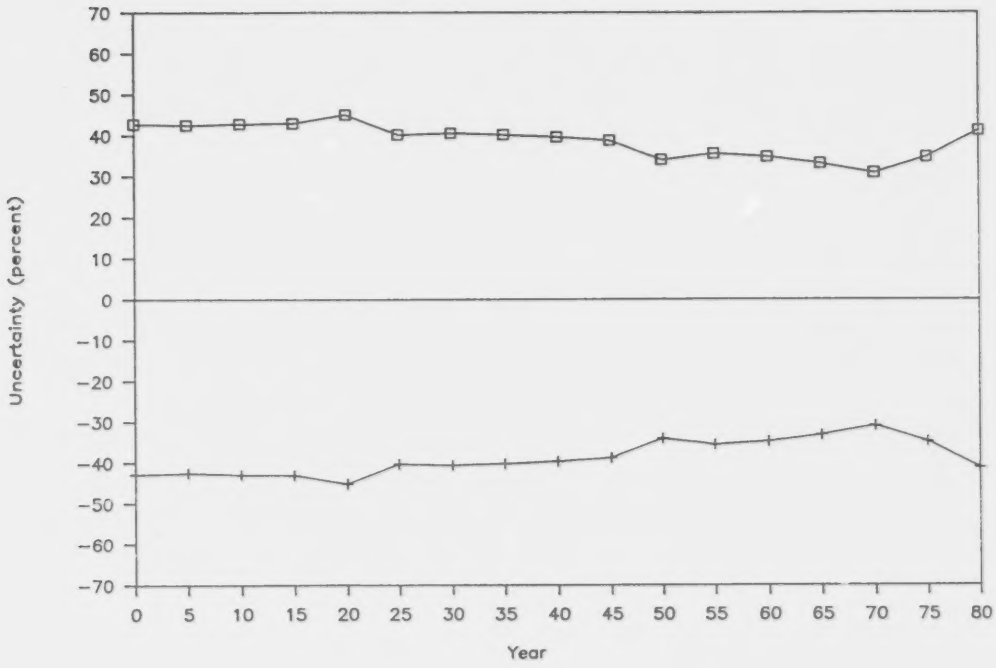

Figure 15. Trend in SO_2 emissions uncertainty based on the illustrative approach.

Note: The uncertainty is primarily affected by the differences in coal sulfur content as estimated by Gschwandtner and Husar as described in Section 2.

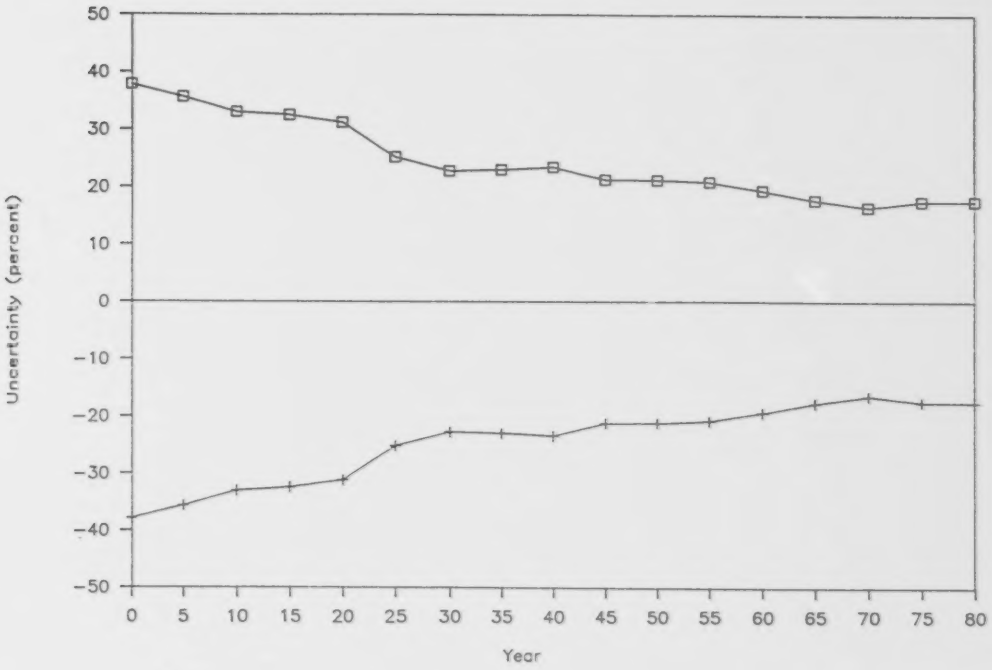

Figure 16. Trend in NO_x emissions uncertainty based on the illustrative approach.

Note: The uncertainty is primarily affected by the uncertainty in historic emission factors.

DISCUSSION

A number of the uncertainty estimates in Table 8 lend themselves to more detailed discussion and explanation. Apparent anomalies and trends in the results of this illustrative example are discussed below.

1. It is counterintuitive that SO_2 uncertainty is greater than NO_x uncertainty. The higher SO_2 uncertainty is an outcome that results from the application of the NAPAP uncertainty methodology; an additional emissions estimation parameter required to estimate SO_2 emissions uncertainty, sulfur content, drives the overall uncertainty higher.

2. SO_2 uncertainty remains relatively constant over time. This outcome is due to two factors: (a) the assumed uncertainty in sulfur content remains nearly constant over time and dominates the emission factor and activity uncertainties in the source category uncertainty calculation, and (b) in early years, emissions are more evenly distributed throughout the various major source categories than in recent years. The first factor resulted from the range in the Husar sulfur content values and the values of Gschwandtner which are shown in Figure 4. Since this dominant factor primarily affects the uncertainty of SO_2 emissions from coal combustion, and since coal was less dominant in the early years, the overall uncertainty in the early year emissions is reduced by applying the NAPAP methodology.

3. The overall uncertainty for SO_2 for the 1980 reference year is 41 percent, compared to 1 percent for the overall uncertainty of the 1980 NAPAP Emissions Inventory.[13] Corresponding uncertainties for NO_x are 18 and 1 percent. These differences are attributable to the different emissions estimation approaches of the two inventories. The 1980 NAPAP inventory is a "bottom-up" inventory: several hundred thousand SCC-level records were aggregated using the uncertainty equations, causing random errors to cancel each other and the overall uncertainty to become very small. Therefore, the assignment of SCC-level uncertainty values to aggregated source categories provides a worst-case analysis of uncertainty in this regard, and was made for illustrative purposes only.

4. In the 1980 NAPAP uncertainty effort, a value of 10 percent sulfur content uncertainty was used. As shown in Figure 7, sulfur content may vary by as much as 67 percent when comparing production and consumption data. This high uncertainty value increases the national SO_2 historic emissions inventory uncertainty to around 40

percent.

5. The SO_2 and NO_x uncertainty values decrease until 1970, when the uncertainty trend reverses. This counter-intuitive result is again a result of applying the NAPAP methodology. The uncertainty procedure requires the aggregation of source categories; in a detailed emissions inventory, many small sources are aggregated and ideally none dominates the overall result. When this method is applied to the historic emissions inventory, which necessarily has fewer and more higher aggregated source categories, the large emissions of some of these categories dominate the result. Since emissions peaked in 1970, each source in the uncertainty calculation is divided by a larger emissions value, and the trend in emissions dictates the uncertainty trend. Hence when emissions are greatest, as in 1970, uncertainty appears to be smallest.

SUMMARY

An illustrative example of a possible uncertainty analysis has been shown. Relying on judgment in the absence of reliable data, the uncertainty estimates have been determined based on a methodology which has been examined in detail by NAPAP. The initial assumptions maybe normalized to reflect the input conditions of the 1980 NAPAP Emissions Inventory uncertainty analysis, which serves as a reference point for this analysis.

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APPENDIX A

ADJUSTED HISTORIC STATE-LEVEL SO_2 EMISSION ESTIMATES

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR TOTAL U.S.

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	412	682	933	1,245	1,552	2,116	2,084	1,527	2,412	3,445	4,495	6,571	9,299	12,625	17,368	18,246	17,335	17,057
INDUSTRIAL	3,229	4,491	5,645	6,771	7,057	7,920	6,730	5,472	6,019	6,973	5,754	5,511	3,898	5,461	4,546	2,927	3,011	2,597
COMMERCIAL-RESIDENTIAL	1,138	1,616	2,095	2,740	2,864	3,316	3,630	3,035	3,697	5,034	4,017	1,983	2,325	1,826	1,501	1,084	1,138	973
HIGHWAY VEHICLES	0	0	0	2	9	21	35	40	51	46	87	128	158	199	284	346	423	458
OTHER	5,209	7,170	8,602	9,532	9,662	9,891	8,627	6,904	7,765	10,509	8,099	6,691	6,634	6,639	7,485	5,662	5,033	4,472
TOTAL	9,988	13,959	17,275	20,290	21,144	23,264	21,106	16,978	19,944	26,007	22,451	20,883	22,314	26,750	31,184	28,245	26,940	25,556

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR ALABAMA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	4	6	8	11	13	15	18	17	33	56	42	204	313	539	744	828	494	531
INDUSTRIAL	31	44	57	70	74	86	68	49	52	57	88	84	42	116	88	110	134	94
COMMERCIAL-RESIDENTIAL	9	14	18	25	27	31	32	25	28	33	34	17	11	4	4	19	22	10
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	1	1	1	2	3	3	5	7	9	10
OTHER	59	76	90	100	110	114	111	99	91	145	104	80	81	71	79	84	92	78
TOTAL	102	138	173	206	224	246	230	189	205	291	268	387	450	734	919	1,049	750	723

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR ARIZONA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	0	0	0	0	2	2	2	2	1	0	0	0	9	4	45	64	80
INDUSTRIAL	0	0	0	1	2	13	13	12	8	9	5	5	5	7	6	9	13	10
COMMERCIAL-RESIDENTIAL	0	1	1	1	1	2	2	2	2	2	2	1	1	1	0	1	1	0
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	0	1	1	2	2	4	5	6	6
OTHER	134	259	343	472	552	738	555	325	586	649	1,044	1,212	1,642	1,861	2,375	1,572	966	778
TOTAL	135	259	344	474	555	755	572	340	598	661	1,052	1,219	1,650	1,879	2,389	1,631	1,051	875

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR ARKANSAS

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	2	4	5	7	8	9	8	5	6	6	1	0	1	0	9	15	64	36
INDUSTRIAL	10	15	20	24	22	19	13	9	8	7	3	7	5	7	5	20	28	19
COMMERCIAL-RESIDENTIAL	7	10	14	19	21	24	24	17	16	14	3	2	1	1	1	8	4	3
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	1	1	1	2	2	3	4	6	6
OTHER	60	83	103	115	135	123	100	78	86	112	71	45	21	16	16	14	14	13
TOTAL	80	112	141	165	186	175	145	109	117	139	80	55	29	26	34	62	116	78

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR CALIFORNIA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	0	0	0	0	3	3	2	1	7	26	47	56	40	40	107	81	81
INDUSTRIAL	5	8	8	13	14	82	70	72	104	129	167	172	101	142	148	90	90	87
COMMERCIAL-RESIDENTIAL	3	4	4	5	5	28	43	64	84	333	168	106	37	11	43	21	21	44
HIGHWAY VEHICLES	0	0	0	0	1	2	3	3	4	4	9	12	17	21	30	32	41	43
OTHER	132	146	195	195	173	389	396	313	266	409	271	244	260	272	287	252	310	311
TOTAL	140	157	207	213	192	504	515	454	459	882	642	582	471	486	548	502	543	564

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR COLORADO

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	2	3	4	5	5	6	5	3	4	6	4	6	22	38	36	53	81	89
INDUSTRIAL	15	21	24	28	27	25	19	15	16	19	14	15	20	20	18	21	20	22
COMMERCIAL-RESIDENTIAL	9	13	16	21	22	25	26	19	20	21	15	8	10	11	6	6	12	2
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	1	1	2	2	2	3	4	5	6
OTHER	48	51	50	48	36	38	42	38	47	35	31	24	27	55	21	20	19	19
TOTAL	73	87	95	102	90	94	92	75	87	81	65	54	81	127	84	105	137	137

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR CONNECTICUT

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	5	8	11	15	17	25	23	18	32	42	60	83	135	199	189	30	26	28
INDUSTRIAL	37	50	60	69	70	79	64	51	52	57	50	46	41	59	43	8	13	9
COMMERCIAL-RESIDENTIAL	6	8	10	12	13	16	17	15	19	21	16	9	46	34	28	15	20	14
HIGHWAY VEHICLES	0	0	0	0	0	0	1	1	1	1	1	2	2	3	4	4	4	5
OTHER	53	74	85	89	88	74	55	44	44	67	43	20	12	9	9	4	3	2
TOTAL	100	139	165	185	187	194	160	128	148	187	170	159	236	304	273	61	67	57

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR DELAWARE

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	0	0	0	0	0	0	0	0	0	0	15	30	44	43	32	36	52
INDUSTRIAL	0	0	0	0	0	6	6	6	6	5	15	17	36	53	20	8	10	11
COMMERCIAL-RESIDENTIAL	0	0	0	0	0	0	0	0	0	0	4	2	8	6	4	5	5	24
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
OTHER	5	6	6	6	6	7	6	6	6	9	13	9	9	7	8	7	7	7
TOTAL	5	6	6	6	6	13	13	12	12	15	32	43	83	110	76	53	60	95

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR DISTRICT OF COLUMBIA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	2	3	4	5	9	8	6	8	8	29	27	18	11	73	9	5	2
INDUSTRIAL	9	11	11	11	10	12	10	8	8	9	4	4	10	5	9	4	1	0
COMMERCIAL-RESIDENTIAL	0	1	1	1	1	1	1	1	2	3	13	6	17	34	32	7	6	3
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
OTHER	8	10	10	10	10	9	11	9	9	13	8	5	3	2	2	1	1	0
TOTAL	19	24	25	25	26	31	30	24	27	32	54	42	47	53	116	22	13	6

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR FLORIDA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	1	1	2	2	27	23	22	35	61	63	117	128	276	412	538	516	617
INDUSTRIAL	1	2	3	4	5	12	12	11	15	28	33	71	59	67	50	50	74	91
COMMERCIAL-RESIDENTIAL	1	1	2	3	3	5	7	9	13	29	18	22	14	7	11	8	17	14
HIGHWAY VEHICLES	0	0	0	0	0	1	1	1	1	1	2	3	4	6	9	14	17	20
OTHER	56	71	88	104	117	132	145	133	116	175	164	155	174	172	199	191	207	199
TOTAL	58	75	94	112	126	176	187	176	180	294	280	367	380	527	681	800	830	942

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR GEORGIA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	3	5	7	9	9	11	9	8	13	21	54	91	113	227	288	528	593	669
INDUSTRIAL	17	23	29	35	39	50	41	29	28	28	17	33	34	50	56	37	42	42
COMMERCIAL-RESIDENTIAL	12	18	23	31	32	37	38	29	30	33	31	19	12	8	11	12	12	2
HIGHWAY VEHICLES	0	0	0	0	0	0	1	1	1	1	2	3	3	5	9	11	13	14
OTHER	55	71	83	89	98	93	90	79	76	116	82	53	46	39	41	35	37	38
TOTAL	87	116	142	164	179	192	179	145	148	199	185	198	208	330	406	624	697	765

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR IDAHO

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INDUSTRIAL	2	3	3	4	4	4	3	3	3	5	11	9	5	11	4	6	7	5
COMMERCIAL-RESIDENTIAL	2	3	4	6	7	8	9	8	10	13	14	11	10	8	4	6	6	5
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2
OTHER	39	55	63	80	65	67	71	56	75	70	82	82	49	119	26	17	18	15
TOTAL	42	61	71	91	76	78	82	66	88	87	107	102	65	139	35	30	33	28

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR ILLINOIS

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	75	124	169	226	288	375	374	262	409	571	741	1,096	1,169	1,515	1,838	1,666	1,312	1,129
INDUSTRIAL	693	931	1,133	1,314	1,252	1,149	927	769	865	1,042	836	732	475	642	387	208	164	157
COMMERCIAL-RESIDENTIAL	281	393	501	645	670	764	855	734	925	1,195	1,000	457	374	244	158	72	54	27
HIGHWAY VEHICLES	0	0	0	0	1	1	2	3	3	3	5	7	8	10	15	17	20	20
OTHER	410	565	685	765	754	678	582	463	467	732	413	244	197	161	157	128	133	122
TOTAL	1,459	2,012	2,488	2,949	2,964	2,968	2,740	2,231	2,669	3,544	2,995	2,536	2,222	2,573	2,554	2,091	1,683	1,456

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR INDIANA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	35	57	78	104	123	138	139	109	189	293	370	582	899	1,201	1,506	1,498	1,331	1,559
INDUSTRIAL	187	281	379	478	572	692	603	474	503	573	462	414	210	315	351	293	272	232
COMMERCIAL-RESIDENTIAL	56	85	118	165	178	203	224	188	233	296	272	124	129	69	44	59	47	29
HIGHWAY VEHICLES	0	0	0	0	0	1	1	1	1	1	3	4	5	6	9	11	12	18
OTHER	174	253	325	379	414	368	309	249	250	415	189	78	57	51	56	47	49	46
TOTAL	451	676	901	1,127	1,286	1,401	1,276	1,021	1,176	1,578	1,295	1,203	1,300	1,643	1,965	1,909	1,711	1,885

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR IOWA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	21	35	48	64	72	76	66	44	64	84	128	119	166	216	224	200	290	220
INDUSTRIAL	190	244	281	322	283	222	173	136	154	176	153	141	103	154	108	63	59	54
COMMERCIAL-RESIDENTIAL	103	138	168	205	208	237	248	190	214	245	210	95	60	31	10	6	8	6
HIGHWAY VEHICLES	0	0	0	0	0	1	1	1	1	1	2	2	3	3	6	6	7	7
OTHER	144	186	210	212	219	181	153	120	111	164	98	49	27	21	20	16	16	15
TOTAL	458	602	706	802	782	717	640	491	543	669	590	406	359	425	368	291	381	302

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR KANSAS

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	9	15	21	28	31	33	28	18	24	29	34	35	35	39	79	129	170	210
INDUSTRIAL	48	60	74	77	74	83	66	48	51	48	39	38	28	23	20	19	23	21
COMMERCIAL-RESIDENTIAL	41	54	65	77	78	89	88	61	59	57	19	9	11	4	2	3	3	1
HIGHWAY VEHICLES	0	0	0	0	0	1	1	1	1	1	1	2	2	3	4	5	5	6
OTHER	163	256	286	266	226	201	166	125	115	171	102	51	31	26	25	21	24	23
TOTAL	261	385	446	447	408	406	348	252	250	306	195	135	108	95	129	176	226	261

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR KENTUCKY

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	9	16	21	28	33	36	40	38	74	126	90	314	424	691	1,118	1,195	1,249	998
INDUSTRIAL	66	85	100	111	123	148	132	108	120	141	141	122	64	107	142	51	54	52
COMMERCIAL-RESIDENTIAL	48	64	79	99	101	115	120	93	105	121	96	44	30	20	20	8	9	13
HIGHWAY VEHICLES	0	0	0	0	0	0	0	1	1	1	1	2	2	3	4	6	8	8
OTHER	85	108	123	126	137	126	119	102	100	160	102	57	44	36	37	34	38	39
TOTAL	208	274	323	364	394	425	412	341	400	548	431	539	565	856	1,321	1,294	1,358	1,109

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR LOUISIANA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	3	6	8	10	14	19	19	11	13	14	0	0	0	0	0	12	60	38
INDUSTRIAL	31	43	54	65	53	36	20	16	12	12	8	16	10	13	12	35	57	63
COMMERCIAL-RESIDENTIAL	9	14	18	24	25	30	31	23	25	46	8	4	2	1	6	15	19	113
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	1	1	1	2	3	3	4	6	7	8
OTHER	97	125	149	163	174	192	186	159	142	192	159	140	151	141	163	173	193	188
TOTAL	141	187	229	262	266	277	256	209	193	264	177	162	166	157	185	241	336	410

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR MAINE

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	2	3	4	6	7	8	7	5	7	8	8	12	16	31	33	19	9	14
INDUSTRIAL	10	16	21	27	28	32	26	21	21	23	11	10	7	10	14	19	21	16
COMMERCIAL-RESIDENTIAL	2	3	4	5	6	7	8	7	9	10	5	4	13	10	16	13	18	10
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2
OTHER	41	56	65	72	76	63	45	37	39	59	33	22	24	19	21	19	20	18
TOTAL	55	77	94	110	116	110	86	71	77	100	57	48	60	72	85	72	70	60

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR MARYLAND

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	3	5	7	10	12	19	20	16	28	43	59	65	128	249	321	192	214	233
INDUSTRIAL	43	56	66	74	68	78	67	61	71	89	89	95	60	81	59	34	39	38
COMMERCIAL-RESIDENTIAL	6	8	10	12	13	15	19	19	28	39	16	8	39	36	29	22	21	17
HIGHWAY VEHICLES	0	0	0	0	0	0	0	1	1	1	1	2	3	4	4	5	6	7
OTHER	60	77	86	89	95	102	94	80	82	135	81	55	48	44	47	38	40	39
TOTAL	112	146	169	185	188	214	200	177	209	307	247	225	278	414	460	292	321	333

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR MASSACHUSETTS

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	12	20	27	36	41	55	47	33	48	59	108	113	145	208	313	97	258	255
INDUSTRIAL	109	138	156	168	163	194	156	121	117	110	58	81	61	58	45	26	19	11
COMMERCIAL-RESIDENTIAL	15	19	23	28	28	36	42	41	56	65	31	19	136	182	141	104	97	48
HIGHWAY VEHICLES	0	0	0	0	0	1	1	1	2	1	2	3	4	4	6	6	8	8
OTHER	91	116	128	129	132	126	107	87	82	129	88	47	28	20	18	7	6	6
TOTAL	226	292	335	361	365	411	353	284	304	365	288	262	374	473	523	241	388	329

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR MICHIGAN

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	20	33	46	61	78	103	107	81	134	199	314	439	485	755	1,175	1,002	813	573
INDUSTRIAL	106	168	224	309	366	470	422	360	413	487	326	305	303	479	305	149	149	122
COMMERCIAL-RESIDENTIAL	28	45	66	96	104	119	138	125	165	222	246	116	137	88	40	27	34	19
HIGHWAY VEHICLES	0	0	0	0	1	1	2	2	3	2	4	6	6	8	11	13	16	15
OTHER	227	359	388	421	341	311	289	204	206	254	175	181	201	211	216	149	116	98
TOTAL	381	605	723	887	890	1,005	968	772	920	1,164	1,065	1,047	1,133	1,541	1,747	1,341	1,128	826

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR MINNESOTA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	7	12	17	22	33	21	17	12	20	29	54	66	104	165	267	189	143	116
INDUSTRIAL	30	42	54	66	78	98	87	71	77	88	39	35	71	66	55	46	24	18
COMMERCIAL-RESIDENTIAL	42	61	82	110	116	133	135	97	100	103	23	12	52	37	33	15	19	10
HIGHWAY VEHICLES	0	0	0	0	0	1	1	1	1	1	2	3	3	4	6	7	8	8
OTHER	123	171	209	230	246	203	160	125	115	172	105	55	36	30	29	24	23	22
TOTAL	202	287	361	428	464	456	399	306	313	394	222	171	266	302	389	280	217	175

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR MISSISSIPPI

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	3	5	7	10	10	6	7	8	18	34	0	1	1	1	41	107	215	131
INDUSTRIAL	8	11	15	19	18	16	13	12	14	18	1	2	3	4	3	12	15	13
COMMERCIAL-RESIDENTIAL	4	6	8	12	12	15	16	14	15	19	2	2	1	0	1	4	5	23
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	1	1	2	2	2	4	4	5	6
OTHER	66	86	105	118	132	124	119	108	105	162	118	85	84	74	84	84	93	89
TOTAL	81	109	136	158	172	161	155	142	152	233	122	91	90	81	132	211	334	262

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR MISSOURI

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	22	36	49	65	77	88	81	55	82	110	84	176	274	422	620	1,004	1,050	1,043
INDUSTRIAL	225	305	365	417	397	364	284	219	236	264	158	145	103	124	120	106	92	70
COMMERCIAL-RESIDENTIAL	110	152	192	243	251	288	304	238	272	320	206	94	76	28	18	13	15	10
HIGHWAY VEHICLES	0	0	0	0	0	1	1	1	2	1	2	4	4	5	7	9	11	11
OTHER	93	148	179	194	190	185	166	122	129	174	122	97	91	261	208	87	87	66
TOTAL	449	641	784	920	915	925	836	636	720	870	572	516	549	840	973	1,218	1,254	1,200

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR MONTANA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	1	1	1	1	1	1	0	0	0	0	0	3	5	9	14	22	29
INDUSTRIAL	7	9	12	14	15	16	12	9	9	9	5	6	8	6	9	10	12	18
COMMERCIAL-RESIDENTIAL	7	10	14	18	19	22	22	17	19	26	12	6	9	7	2	3	6	1
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	3	3
OTHER	296	366	346	324	223	317	290	268	378	243	276	358	340	320	418	170	141	115
TOTAL	310	386	373	358	258	356	326	296	407	278	293	370	362	340	439	199	184	166

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR NEBRASKA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	11	18	25	33	37	42	35	22	28	33	12	11	22	40	35	28	49	47
INDUSTRIAL	48	60	68	72	63	49	33	24	23	24	15	14	12	23	22	9	10	5
COMMERCIAL-RESIDENTIAL	33	43	52	61	62	71	70	48	47	44	12	6	9	4	5	3	4	1
HIGHWAY VEHICLES	0	0	0	0	0	0	1	1	0	1	1	1	1	2	3	3	4	4
OTHER	101	130	145	143	146	120	98	77	71	105	62	30	19	14	16	13	16	11
TOTAL	192	251	288	309	307	282	236	172	170	205	102	62	62	84	81	54	82	68

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR NEVADA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	0	0	0	0	0	0	0	0	0	0	0	0	5	7	32	37	43
INDUSTRIAL	1	2	3	3	4	5	4	3	3	4	2	2	1	2	2	3	3	3
COMMERCIAL-RESIDENTIAL	1	1	1	2	2	3	3	2	2	2	1	1	2	2	1	1	1	1
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2
OTHER	5	8	80	82	67	93	95	88	163	130	148	221	241	197	311	252	225	190
TOTAL	7	11	84	88	73	100	102	93	168	136	152	224	245	206	323	288	268	239

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR NEW HAMPSHIRE

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	2	2	3	4	6	5	3	5	4	7	12	16	25	66	59	51	69
INDUSTRIAL	9	12	14	16	16	17	13	11	11	12	4	5	4	7	14	6	4	4
COMMERCIAL-RESIDENTIAL	1	2	2	3	3	4	4	4	5	6	4	2	6	7	8	7	9	6
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
OTHER	33	44	49	51	53	42	25	20	23	32	15	7	5	4	3	2	2	2
TOTAL	45	60	68	74	76	68	48	38	45	55	30	26	32	43	92	75	67	81

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR NEW JERSEY

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	12	20	27	36	46	82	77	56	81	97	132	150	208	363	290	110	103	102
INDUSTRIAL	44	67	91	119	132	207	180	153	156	161	174	172	108	131	94	52	38	42
COMMERCIAL-RESIDENTIAL	1	2	2	3	3	6	8	9	16	49	23	13	57	72	87	65	68	64
HIGHWAY VEHICLES	0	0	0	0	0	1	1	2	2	2	3	5	6	7	10	12	12	13
OTHER	217	310	381	433	472	483	470	374	386	619	279	166	126	112	108	88	99	97
TOTAL	274	398	502	592	654	777	735	594	642	928	610	506	505	685	588	327	320	317

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR NEW MEXICO

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980	1980
ELECTRIC UTILITIES	0	0	1	1	1	1	1	1	1	1	1	0	1	55	90	80	100	107
INDUSTRIAL	1	2	3	4	5	7	6	4	4	4	3	2	4	2	2	5	6	5
COMMERCIAL-RESIDENTIAL	1	1	0	2	2	4	4	3	3	3	3	2	2	1	1	2	2	1
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	0	1	1	2	2	2	3	4	4
OTHER	39	48	54	121	111	136	129	64	191	201	204	213	218	261	449	442	203	179
TOTAL	41	51	59	129	120	148	140	72	198	208	211	219	227	320	544	532	315	297

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR NEW YORK

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	25	42	57	76	105	179	176	122	177	230	347	352	568	678	646	546	498	442
INDUSTRIAL	179	245	302	358	375	428	372	304	342	385	363	320	201	314	302	131	130	150
COMMERCIAL-RESIDENTIAL	20	28	37	48	50	60	66	57	69	87	77	42	273	334	270	227	263	185
HIGHWAY VEHICLES	0	0	0	0	1	2	4	4	4	3	6	8	9	12	14	14	17	17
OTHER	470	634	726	769	806	708	627	496	527	704	468	251	179	118	107	57	57	55
TOTAL	695	949	1,122	1,251	1,337	1,377	1,245	983	1,120	1,409	1,261	974	1,230	1,456	1,339	975	965	851

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR NORTH CAROLINA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	2	3	4	5	10	20	25	20	34	54	91	134	129	225	412	410	422	408
INDUSTRIAL	6	11	16	22	35	54	56	52	64	82	74	69	51	74	71	53	75	62
COMMERCIAL-RESIDENTIAL	6	11	17	27	29	34	41	40	56	78	84	46	44	24	25	17	19	16
HIGHWAY VEHICLES	0	0	0	0	0	0	1	1	1	1	2	3	4	5	7	9	12	13
OTHER	38	51	66	79	90	87	85	74	69	110	83	58	64	46	48	41	42	38
TOTAL	52	76	103	132	164	196	208	186	224	325	333	310	292	373	564	530	570	536

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR NORTH DAKOTA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	2	4	5	7	7	8	7	5	8	11	26	32	17	16	32	44	71	88
INDUSTRIAL	1	1	2	3	3	2	1	1	1	2	3	4	8	9	7	6	7	5
COMMERCIAL-RESIDENTIAL	1	2	4	6	7	8	8	6	7	8	10	5	14	9	4	5	4	6
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	1	2	2
OTHER	12	18	24	28	31	27	21	18	16	24	18	14	16	14	14	13	15	14
TOTAL	15	25	34	44	48	44	38	31	33	44	67	56	55	48	59	69	98	116

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR OHIO

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	54	89	122	162	195	230	230	174	292	440	654	870	1,479	1,701	2,202	2,492	2,276	2,225
INDUSTRIAL	497	670	816	953	987	1,068	925	767	866	1,041	895	800	596	861	757	376	339	233
COMMERCIAL-RESIDENTIAL	104	147	188	244	254	290	331	294	380	503	583	267	171	109	72	48	44	38
HIGHWAY VEHICLES	0	0	0	0	1	1	2	2	3	3	5	7	8	11	14	18	21	23
OTHER	327	444	528	564	609	523	461	370	357	579	294	127	96	83	86	69	72	70
TOTAL	982	1,349	1,654	1,923	2,046	2,112	1,950	1,607	1,899	2,566	2,431	2,071	2,351	2,765	3,132	3,003	2,751	2,588

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR OKLAHOMA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	2	4	5	7	13	30	30	19	23	27	8	1	0	0	0	2	11	56
INDUSTRIAL	9	18	29	44	43	46	35	28	25	25	12	40	23	27	9	9	22	20
COMMERCIAL-RESIDENTIAL	8	17	29	47	53	61	60	40	39	35	4	3	2	1	1	2	3	2
HIGHWAY VEHICLES	0	0	0	0	0	0	1	1	1	1	1	2	3	3	4	6	8	9
OTHER	48	89	172	251	269	290	219	173	184	242	202	180	140	85	74	60	63	52
TOTAL	67	127	235	348	378	426	344	261	272	330	227	225	167	116	89	80	106	140

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR OREGON

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	0	0	0	0	13	10	9	7	12	16	17	0	0	0	1	1	12
INDUSTRIAL	1	2	3	5	4	14	13	14	14	18	22	24	12	13	15	13	14	14
COMMERCIAL-RESIDENTIAL	1	2	3	4	5	6	7	7	8	14	12	8	26	21	19	13	9	8
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	1	1	1	2	2	3	4	5	7	7
OTHER	11	16	20	24	28	34	33	27	23	46	28	19	17	16	17	13	17	15
TOTAL	13	20	26	33	37	68	64	57	54	90	79	70	57	52	55	45	47	55

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR PENNSYLVANIA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	24	39	54	71	111	193	205	140	212	290	458	539	681	920	1,503	1,348	1,150	1,343
INDUSTRIAL	315	503	716	935	1,054	1,268	1,054	768	780	822	697	674	459	448	498	307	289	233
COMMERCIAL-RESIDENTIAL	24	39	56	82	89	103	116	101	129	181	186	86	122	107	101	73	74	96
HIGHWAY VEHICLES	0	0	0	0	0	1	2	3	4	3	5	7	9	10	14	19	21	22
OTHER	383	523	606	664	725	648	465	399	451	622	495	445	399	276	250	180	194	153
TOTAL	745	1,103	1,432	1,753	1,980	2,213	1,842	1,410	1,575	1,918	1,841	1,751	1,669	1,762	2,366	1,927	1,728	1,846

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR RHODE ISLAND

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	2	3	4	5	5	25	20	17	20	15	28	25	28	24	23	5	4	4
INDUSTRIAL	15	19	22	23	23	38	33	28	29	25	22	31	24	8	8	4	3	2
COMMERCIAL-RESIDENTIAL	2	3	4	4	4	6	7	7	10	11	16	19	22	10	20	10	11	4
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
OTHER	31	40	44	45	46	38	22	18	20	26	13	7	4	3	3	1	1	1
TOTAL	50	65	73	77	78	107	82	70	78	77	79	81	79	46	55	21	20	12

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR SOUTH CAROLINA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	2	3	4	6	10	10	7	10	14	22	30	41	69	119	134	193	192
INDUSTRIAL	3	5	8	11	16	25	28	30	42	58	51	50	43	46	53	38	62	51
COMMERCIAL-RESIDENTIAL	4	7	10	16	18	20	22	18	22	27	35	20	18	10	10	5	5	7
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	1	1	2	2	3	4	5	6	7
OTHER	23	33	42	50	58	54	54	44	43	66	44	25	19	15	17	11	12	11
TOTAL	32	47	64	82	98	109	115	100	118	166	154	126	122	141	202	194	278	270

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR SOUTH DAKOTA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	2	4	5	7	8	7	6	5	8	13	13	12	5	5	53	31	47	36
INDUSTRIAL	1	1	2	2	2	1	1	1	2	2	3	3	3	8	3	3	4	3
COMMERCIAL-RESIDENTIAL	3	4	5	7	7	8	8	7	8	9	4	2	6	5	2	1	1	1
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2
OTHER	9	12	15	15	16	14	11	9	8	11	8	5	5	3	2	1	2	1
TOTAL	15	21	27	31	33	31	27	22	26	35	28	23	21	22	62	38	55	44

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR TENNESSEE

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	4	7	10	13	15	17	25	28	62	114	19	227	642	560	849	1,265	900	951
INDUSTRIAL	33	44	52	60	67	81	83	83	108	145	120	109	61	136	84	49	142	82
COMMERCIAL-RESIDENTIAL	40	56	70	89	92	105	119	105	135	179	212	96	38	24	14	8	10	9
HIGHWAY VEHICLES	0	0	0	0	0	0	1	1	1	1	1	2	3	4	6	9	12	11
OTHER	72	101	118	122	128	123	99	107	112	161	90	75	75	68	79	58	41	36
TOTAL	150	208	250	284	303	327	327	324	417	601	441	509	820	792	1,032	1,388	1,105	1,089

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR TEXAS

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	7	11	15	20	27	40	37	23	27	29	0	0	0	0	1	80	183	282
INDUSTRIAL	38	48	54	60	53	99	88	80	89	95	52	110	77	63	47	121	140	143
COMMERCIAL-RESIDENTIAL	19	26	31	37	37	44	45	35	45	182	34	33	7	3	12	36	42	10
HIGHWAY VEHICLES	0	0	0	0	1	1	2	2	3	3	6	9	11	13	18	24	33	36
OTHER	325	395	446	471	479	595	585	521	465	716	685	728	783	694	817	847	944	854
TOTAL	389	479	546	588	597	779	758	660	630	1,024	777	880	878	773	895	1,107	1,342	1,326

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR UTAH

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	0	0	0	0	0	0	1	1	2	2	9	17	12	10	18	26	26
INDUSTRIAL	4	6	8	10	12	14	13	11	12	15	56	50	24	29	24	26	25	16
COMMERCIAL-RESIDENTIAL	6	10	14	19	21	24	25	19	21	24	17	9	10	8	5	6	7	10
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2	3	3
OTHER	51	93	179	242	156	314	254	178	529	530	511	336	252	339	252	64	60	56
TOTAL	61	108	201	271	189	352	291	208	564	571	588	406	304	388	293	117	122	111

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR VERMONT

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	2	2	3	3	2	3	2	2	3	0	2	1	2	4	0	0	0
INDUSTRIAL	6	8	11	13	13	12	10	7	8	8	1	1	2	2	2	1	1	1
COMMERCIAL-RESIDENTIAL	1	1	2	2	3	3	3	3	4	4	1	1	4	6	4	3	5	4
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
OTHER	27	36	39	41	42	33	17	14	16	21	9	5	3	2	2	1	1	1
TOTAL	35	47	53	59	60	52	33	26	30	37	12	9	9	12	12	6	8	7

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR VIRGINIA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	5	7	10	14	17	23	23	19	31	47	81	97	161	211	274	208	224	151
INDUSTRIAL	22	34	44	57	60	62	62	64	86	116	120	109	81	121	92	63	54	63
COMMERCIAL-RESIDENTIAL	8	13	18	26	28	33	43	45	67	94	114	62	57	44	54	30	25	19
HIGHWAY VEHICLES	0	0	0	0	0	0	1	1	1	1	2	3	4	6	7	9	10	11
OTHER	58	81	103	119	136	133	127	108	106	184	109	68	48	41	46	37	37	38
TOTAL	93	136	175	216	241	251	256	226	290	442	425	338	350	422	474	347	350	279

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR WASHINGTON

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	1	1	2	2	1	1	0	0	1	0	1	0	0	0	35	90	78
INDUSTRIAL	3	5	6	10	11	28	24	23	22	43	53	71	25	24	34	33	36	33
COMMERCIAL-RESIDENTIAL	4	6	9	13	14	17	18	15	17	26	21	14	50	33	26	16	14	21
HIGHWAY VEHICLES	0	0	0	0	0	0	1	1	1	1	2	2	3	3	5	6	8	8
OTHER	29	43	56	66	73	79	76	61	68	94	129	114	110	100	105	105	154	135
TOTAL	36	55	73	90	100	126	119	100	108	164	205	203	187	160	170	193	302	276

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR WEST VIRGINIA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	5	8	10	14	26	50	57	41	66	95	130	211	323	438	733	1,217	1,097	1,005
INDUSTRIAL	32	51	73	99	107	112	99	89	106	131	138	128	84	280	146	111	85	64
COMMERCIAL-RESIDENTIAL	4	7	10	15	16	19	20	16	19	24	23	11	11	10	36	5	8	7
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	1	1	1	2	2	3	3	3	4
OTHER	44	69	97	126	128	149	117	98	84	136	92	57	51	41	45	45	49	45
TOTAL	84	134	190	254	277	330	293	245	275	385	384	406	470	771	963	1,381	1,241	1,125

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR WISCONSIN

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	13	21	29	39	45	51	50	40	69	108	162	229	275	353	598	520	592	496
INDUSTRIAL	80	111	140	169	214	290	271	228	258	309	126	110	126	206	174	61	67	63
COMMERCIAL-RESIDENTIAL	44	64	85	113	120	136	146	116	136	164	77	36	136	97	56	24	20	11
HIGHWAY VEHICLES	0	0	0	0	0	1	1	1	1	1	2	3	3	4	6	7	10	10
OTHER	119	161	192	210	224	187	151	120	111	165	115	65	47	41	43	35	38	34
TOTAL	256	358	446	531	603	665	619	505	575	747	482	443	587	701	877	648	728	613

SUMMARY OF SO2 EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR WYOMING

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	1	2	2	2	2	2	1	2	3	3	5	19	45	38	72	114	159
INDUSTRIAL	4	5	5	5	5	9	8	7	9	12	14	11	6	11	9	14	24	25
COMMERCIAL-RESIDENTIAL	3	4	4	5	5	5	6	4	4	17	3	2	4	3	3	4	8	2
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2
OTHER	21	20	21	21	20	22	21	19	17	27	27	26	32	30	34	34	38	37
TOTAL	28	29	32	32	32	38	37	32	32	58	47	45	61	90	84	125	187	226

APPENDIX B

ADJUSTED HISTORIC STATE-LEVEL NO_X EMISSION ESTIMATES

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR TOTAL U.S.

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	99	165	225	300	383	544	557	418	642	950	1,295	1,943	2,480	3,469	4,893	5,680	6,407	7,008
INDUSTRIAL	691	965	1,433	1,724	1,860	2,307	2,361	1,880	2,487	2,824	3,232	3,618	4,107	5,267	4,300	3,794	4,114	3,352
COMMERCIAL-RESIDENTIAL	72	103	142	187	200	234	263	226	579	410	746	363	760	711	835	793	841	752
HIGHWAY VEHICLES	0	2	14	71	249	536	903	1,006	1,478	1,170	2,341	2,895	3,999	4,412	6,586	7,861	8,441	7,983
OTHER	1,749	2,080	2,289	2,391	2,467	3,681	3,934	3,109	2,268	4,194	2,692	2,744	2,691	2,720	3,288	3,061	3,554	3,289
TOTAL	2,611	3,314	4,102	4,672	5,159	7,302	8,018	6,639	7,454	9,548	10,306	11,563	14,037	16,579	19,902	21,189	23,358	22,384

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR ALABAMA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	2	2	3	4	4	5	5	9	17	15	61	82	146	177	203	154	187
INDUSTRIAL	10	14	18	22	24	26	21	22	28	33	51	61	53	86	66	65	70	74
COMMERCIAL-RESIDENTIAL	1	1	1	2	2	2	3	2	5	3	10	6	7	6	7	9	10	7
HIGHWAY VEHICLES	0	0	0	1	3	6	10	10	17	17	36	50	74	82	108	152	171	164
OTHER	81	84	87	88	89	102	73	76	39	69	42	47	53	48	70	83	113	74
TOTAL	92	100	108	116	122	141	111	115	97	139	154	224	270	368	429	512	519	507

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR ARIZONA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	0	0	0	0	1	1	1	1	1	3	6	13	13	19	55	102	140
INDUSTRIAL	0	0	0	0	1	4	3	8	9	10	22	30	25	42	36	30	30	36
COMMERCIAL-RESIDENTIAL	0	0	0	0	0	0	0	0	1	1	2	2	3	3	3	4	4	4
HIGHWAY VEHICLES	0	0	0	0	1	2	4	4	7	7	16	22	38	42	77	100	112	106
OTHER	3	4	5	6	6	25	23	20	15	21	16	10	20	25	26	23	36	33
TOTAL	3	4	5	6	8	31	32	33	33	38	60	69	99	124	162	211	285	319

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR ARKANSAS

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	1	1	1	1	2	2	1	1	3	5	12	11	16	27	12	38	51
INDUSTRIAL	2	2	3	4	12	30	19	11	16	33	55	69	55	72	42	32	39	33
COMMERCIAL-RESIDENTIAL	0	1	1	1	1	2	2	1	3	2	8	4	5	5	6	7	7	5
HIGHWAY VEHICLES	0	0	0	1	2	5	8	8	12	12	26	32	46	53	73	92	105	97
OTHER	156	158	160	161	161	176	121	54	38	40	35	26	30	26	33	44	46	44
TOTAL	158	161	164	167	178	213	151	75	71	89	128	143	146	172	181	187	235	229

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR CALIFORNIA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	0	0	0	1	4	8	4	4	12	32	69	103	152	169	151	163	194
INDUSTRIAL	3	4	19	16	37	116	168	98	151	159	228	277	194	236	220	205	177	166
COMMERCIAL-RESIDENTIAL	1	1	1	1	2	5	8	10	27	39	50	15	33	36	48	54	51	53
HIGHWAY VEHICLES	0	0	1	6	22	46	72	83	120	111	212	238	381	420	649	705	788	711
OTHER	46	53	59	60	62	454	492	398	272	567	249	266	245	310	383	312	371	379
TOTAL	49	58	80	84	124	625	747	592	573	889	771	864	956	1,154	1,468	1,428	1,549	1,504

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR COLORADO

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	2	3	4	5	6	6	5	3	5	7	9	14	22	32	48	81	107	125
INDUSTRIAL	15	20	24	28	27	24	25	18	23	25	31	40	36	41	20	31	32	33
COMMERCIAL-RESIDENTIAL	2	3	3	4	5	5	6	4	9	5	8	5	7	8	10	12	12	10
HIGHWAY VEHICLES	0	0	0	1	2	4	6	7	10	8	17	24	36	39	61	80	89	92
OTHER	8	10	12	13	13	14	13	11	9	22	19	22	26	32	32	33	38	50
TOTAL	26	36	44	51	52	53	54	43	55	67	84	105	128	151	171	236	279	309

SUMMARY OF NOx EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR CONNECTICUT

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	2	3	4	5	6	9	8	6	10	14	18	29	33	50	45	26	23	22
INDUSTRIAL	10	14	16	19	19	21	17	14	16	16	13	14	16	20	15	9	14	11
COMMERCIAL-RESIDENTIAL	0	1	1	1	1	2	2	2	6	3	6	3	17	12	14	13	15	12
HIGHWAY VEHICLES	0	0	0	1	4	8	14	17	25	17	26	34	46	53	93	101	95	91
OTHER	20	26	29	30	30	28	21	16	14	26	24	24	17	19	26	19	15	10
TOTAL	33	43	50	56	60	67	62	55	70	75	88	104	129	154	191	168	163	145

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR DELAWARE

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	0	0	0	0	0	0	0	0	0	0	6	9	14	20	18	19	20
INDUSTRIAL	0	0	0	0	0	2	2	2	2	1	4	5	13	18	7	4	5	5
COMMERCIAL-RESIDENTIAL	0	0	0	0	0	0	0	0	0	0	5	1	3	2	3	3	3	4
HIGHWAY VEHICLES	0	0	0	0	1	1	2	3	4	3	6	8	12	14	17	20	22	22
OTHER	3	3	3	3	4	3	4	3	3	5	5	5	5	5	8	6	5	10
TOTAL	3	3	3	4	4	6	7	7	9	9	20	24	42	52	54	50	54	61

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR DISTRICT OF COLUMBIA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	1	1	1	2	2	2	1	2	2	9	8	5	4	13	4	6	2
INDUSTRIAL	4	4	4	4	4	4	4	3	3	3	1	2	4	2	4	3	1	0
COMMERCIAL-RESIDENTIAL	0	0	0	0	0	0	0	0	0	0	3	1	4	6	8	4	4	3
HIGHWAY VEHICLES	0	0	0	0	1	3	5	7	11	7	9	9	11	12	17	17	18	15
OTHER	3	4	4	4	4	4	5	4	4	8	8	8	4	4	6	4	3	2
TOTAL	7	9	10	10	11	14	16	16	21	20	30	29	29	28	47	31	32	23

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR FLORIDA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	0	0	0	0	5	5	4	7	13	14	26	48	80	154	170	181	185
INDUSTRIAL	0	1	1	1	1	3	3	3	5	10	13	26	30	47	26	30	39	51
COMMERCIAL-RESIDENTIAL	0	0	0	0	0	0	1	1	3	3	6	5	5	5	7	6	8	6
HIGHWAY VEHICLES	0	0	0	2	6	13	14	16	26	22	48	73	117	134	236	352	365	385
OTHER	52	55	57	60	61	89	337	314	109	173	112	122	80	76	102	82	94	87
TOTAL	53	55	59	63	69	111	359	338	149	220	193	251	281	342	525	641	688	715

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR GEORGIA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	1	1	2	2	2	2	2	4	8	17	27	35	61	98	168	191	201
INDUSTRIAL	5	8	9	11	13	16	13	12	13	19	25	42	42	59	36	30	32	39
COMMERCIAL-RESIDENTIAL	1	2	2	3	3	3	3	3	6	4	15	8	10	9	10	11	12	13
HIGHWAY VEHICLES	0	0	0	1	4	8	13	16	25	23	47	66	94	115	188	245	256	240
OTHER	65	68	71	72	73	75	117	80	67	58	83	63	53	54	72	60	66	67
TOTAL	72	79	84	89	94	104	148	112	116	110	187	207	234	298	404	514	557	560

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR IDAHO

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40
INDUSTRIAL	1	2	2	2	2	2	2	1	2	2	5	4	8	13	10	13	13	12
COMMERCIAL-RESIDENTIAL	0	1	1	1	1	1	1	1	3	2	4	2	4	3	3	4	3	3
HIGHWAY VEHICLES	0	0	0	0	1	2	3	4	6	6	14	17	21	23	28	36	43	35
OTHER	5	7	9	10	10	12	11	9	7	14	9	12	14	13	18	23	26	24
TOTAL	7	9	11	13	14	17	17	16	18	24	32	34	46	52	59	76	85	113

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR ILLINOIS

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	14	22	31	41	52	68	69	48	74	104	143	213	223	297	364	386	393	391
INDUSTRIAL	106	142	176	201	192	180	149	141	181	200	207	211	205	244	139	94	91	90
COMMERCIAL-RESIDENTIAL	13	18	23	30	31	35	39	35	88	57	71	33	74	63	65	58	62	45
HIGHWAY VEHICLES	0	0	1	5	16	35	58	63	96	68	122	146	191	216	336	378	379	346
OTHER	74	92	103	107	111	111	91	76	56	114	105	113	146	141	169	160	141	146
TOTAL	206	274	333	383	402	429	406	363	495	544	648	715	839	960	1,072	1,075	1,065	1,017

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR INDIANA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	7	11	15	20	24	27	27	23	38	58	72	115	152	212	258	305	311	348
INDUSTRIAL	31	46	63	79	95	118	104	87	105	113	96	96	88	128	103	78	85	86
COMMERCIAL-RESIDENTIAL	4	5	8	11	11	13	14	12	30	19	29	13	29	23	26	28	28	21
HIGHWAY VEHICLES	0	0	0	2	8	17	27	29	44	36	76	98	128	141	202	240	243	312
OTHER	32	40	47	51	54	52	51	40	31	61	43	56	59	59	82	65	65	73
TOTAL	74	103	133	163	192	227	222	190	247	288	317	379	456	563	671	715	733	839

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR IOWA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	3	5	7	10	11	12	10	8	11	15	25	29	35	43	65	69	105	113
INDUSTRIAL	27	34	40	45	39	31	23	23	29	32	43	54	47	64	50	43	29	39
COMMERCIAL-RESIDENTIAL	5	6	7	9	9	11	11	9	20	12	16	8	15	12	12	12	11	9
HIGHWAY VEHICLES	0	0	0	2	7	14	22	24	33	27	52	59	76	78	119	129	126	116
OTHER	23	26	28	28	29	27	23	20	16	33	34	43	34	32	45	42	38	30
TOTAL	57	72	83	94	95	94	90	84	110	118	171	193	207	229	290	295	308	308

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR KANSAS

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	2	3	4	5	6	7	6	8	11	15	20	25	31	52	69	114	149
INDUSTRIAL	8	10	48	30	25	38	39	27	38	59	92	116	99	122	132	135	130	109
COMMERCIAL-RESIDENTIAL	3	4	6	7	6	7	7	5	12	6	9	6	8	8	8	9	11	8
HIGHWAY VEHICLES	0	0	0	2	6	12	19	18	24	19	39	47	59	65	86	99	99	104
OTHER	20	24	27	27	27	67	63	52	39	90	52	52	46	46	56	60	88	80
TOTAL	33	41	84	69	69	131	136	109	120	186	207	241	236	271	335	372	443	449

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR KENTUCKY

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	2	3	4	6	7	7	8	8	15	26	19	65	83	141	213	269	264	255
INDUSTRIAL	12	16	20	22	26	32	28	22	28	31	44	54	57	75	77	52	54	52
COMMERCIAL-RESIDENTIAL	3	4	5	6	6	7	8	6	14	8	14	7	11	9	12	10	12	12
HIGHWAY VEHICLES	0	0	0	1	3	6	10	12	19	17	40	50	65	73	114	147	157	138
OTHER	21	23	25	25	26	27	40	24	25	40	34	40	44	42	44	51	79	109
TOTAL	38	46	54	60	69	80	93	72	101	121	150	216	260	340	460	529	566	566

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR LOUISIANA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	1	1	2	3	5	8	6	9	13	15	18	28	46	78	87	116	129
INDUSTRIAL	5	7	8	23	33	91	97	52	77	126	197	276	393	569	517	529	860	402
COMMERCIAL-RESIDENTIAL	0	1	1	1	1	2	2	2	6	6	7	5	6	5	10	13	13	17
HIGHWAY VEHICLES	0	0	0	1	3	7	11	11	17	16	36	48	72	76	100	127	139	140
OTHER	37	41	44	46	48	129	154	128	82	116	80	102	118	118	170	206	265	212
TOTAL	43	49	54	73	88	233	271	199	190	277	336	448	618	814	876	960	1,392	901

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR MAINE

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	2	2	3	3	4	3	2	3	3	2	2	3	6	6	3	2	4
INDUSTRIAL	4	6	9	10	10	11	9	7	8	8	4	4	3	5	6	7	10	8
COMMERCIAL-RESIDENTIAL	0	0	0	1	1	1	1	1	3	2	4	2	5	5	7	6	8	5
HIGHWAY VEHICLES	0	0	0	1	2	4	6	7	10	8	16	19	26	27	36	41	44	39
OTHER	19	24	26	28	29	24	16	13	12	22	13	14	13	11	15	12	10	10
TOTAL	24	32	37	42	45	43	35	31	35	42	38	42	51	53	69	70	74	66

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR MASSACHUSETTS

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	5	8	11	15	17	20	18	12	17	22	27	34	42	65	57	48	56	52
INDUSTRIAL	35	44	50	54	52	59	47	36	39	34	15	29	29	27	19	13	13	10
COMMERCIAL-RESIDENTIAL	1	2	2	3	3	5	6	7	20	10	13	8	39	44	46	42	42	26
HIGHWAY VEHICLES	0	0	1	3	11	23	33	36	48	33	53	63	87	93	145	160	172	164
OTHER	37	44	48	48	49	61	57	47	34	76	54	52	38	37	43	28	21	21
TOTAL	77	98	111	122	131	168	161	139	159	174	162	186	234	266	309	290	304	274

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR MICHIGAN

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	5	8	11	14	18	24	25	19	31	47	76	105	116	187	270	257	265	250
INDUSTRIAL	24	37	52	70	82	105	98	85	108	119	90	89	136	193	121	92	82	90
COMMERCIAL-RESIDENTIAL	3	4	6	9	9	11	13	12	32	22	43	22	43	40	42	43	43	41
HIGHWAY VEHICLES	0	0	1	4	13	27	45	48	75	56	104	131	168	189	294	326	346	289
OTHER	43	48	53	57	59	61	49	35	24	52	54	57	54	68	85	69	59	44
TOTAL	74	98	123	153	181	228	230	199	270	297	367	403	516	677	813	788	794	714

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR MINNESOTA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	2	2	4	5	4	3	3	4	8	16	21	28	39	57	72	77	78
INDUSTRIAL	5	7	8	10	12	15	14	15	19	24	22	30	32	42	28	23	23	26
COMMERCIAL-RESIDENTIAL	5	7	9	12	13	14	15	11	23	12	11	7	16	16	19	19	21	15
HIGHWAY VEHICLES	0	0	0	2	7	14	21	23	34	25	50	61	86	89	133	155	165	151
OTHER	39	47	53	56	58	52	39	28	23	40	35	40	53	49	54	52	44	47
TOTAL	49	63	74	84	94	100	92	79	103	108	134	159	216	234	292	320	330	317

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR MISSISSIPPI

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	2	2	2	3	2	2	2	5	10	4	8	8	14	29	35	52	62
INDUSTRIAL	2	4	5	6	6	5	5	7	10	18	36	56	66	97	95	69	56	61
COMMERCIAL-RESIDENTIAL	0	1	1	1	1	1	1	1	2	2	8	5	5	4	4	5	6	6
HIGHWAY VEHICLES	0	0	0	1	2	5	8	8	14	13	30	37	50	54	76	92	101	97
OTHER	44	48	51	52	55	54	58	102	86	84	53	47	42	37	53	50	73	59
TOTAL	48	53	58	63	66	67	74	121	118	127	132	153	170	205	257	251	289	284

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR MISSOURI

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	3	5	7	10	12	14	13	10	15	21	19	33	112	76	142	194	235	230
INDUSTRIAL	33	44	53	63	58	53	51	41	51	59	63	65	60	73	33	38	33	31
COMMERCIAL-RESIDENTIAL	4	6	7	9	10	11	12	10	23	14	22	12	21	15	18	18	21	16
HIGHWAY VEHICLES	0	0	0	2	6	13	27	31	45	34	71	85	113	120	162	190	204	189
OTHER	41	44	46	46	47	63	46	42	35	68	57	75	82	86	81	73	84	71
TOTAL	81	99	113	130	132	154	149	134	169	196	232	270	388	368	436	514	576	537

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR MONTANA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	1	1	1	1	1	1	0	0	1	0	0	2	4	8	13	37	36
INDUSTRIAL	4	5	7	8	9	9	9	9	11	11	9	10	10	13	12	11	13	16
COMMERCIAL-RESIDENTIAL	1	2	2	3	3	3	4	3	7	4	5	3	4	4	3	3	4	3
HIGHWAY VEHICLES	0	0	0	0	1	2	4	5	7	5	14	17	23	27	33	39	46	40
OTHER	16	19	21	22	23	34	26	24	23	63	39	33	39	29	31	33	32	43
TOTAL	21	26	30	34	36	49	43	41	48	84	68	63	78	76	87	100	131	138

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR NEBRASKA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	2	3	4	5	6	6	5	4	6	5	5	7	10	14	17	25	36	51
INDUSTRIAL	8	10	11	12	11	8	6	7	8	11	21	26	22	32	26	23	22	19
COMMERCIAL-RESIDENTIAL	2	3	4	5	5	5	5	4	8	4	5	4	5	5	7	7	7	5
HIGHWAY VEHICLES	0	0	0	1	4	8	13	12	14	12	28	35	42	43	60	73	76	67
OTHER	17	20	22	22	22	22	17	15	11	22	19	24	30	31	45	43	63	33
TOTAL	29	36	41	45	47	49	46	41	47	54	77	95	109	125	154	171	204	176

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR NEVADA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	0	0	0	0	0	0	0	0	0	0	1	2	5	12	54	49	54
INDUSTRIAL	1	1	1	2	2	3	2	2	1	2	1	5	2	3	2	2	2	3
COMMERCIAL-RESIDENTIAL	0	0	0	0	0	0	0	0	0	0	1	0	1	1	2	2	7	2
HIGHWAY VEHICLES	0	0	0	0	0	1	1	1	2	2	6	8	12	16	22	28	34	35
OTHER	2	3	3	4	5	39	36	30	19	52	26	18	13	14	12	6	12	14
TOTAL	2	4	5	6	7	42	40	33	24	56	33	31	29	39	49	92	104	108

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR NEW HAMPSHIRE

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	1	1	2	2	2	2	1	2	2	1	2	3	6	14	14	12	16
INDUSTRIAL	3	4	5	6	6	6	5	4	4	4	1	2	2	3	5	2	3	2
COMMERCIAL-RESIDENTIAL	0	0	0	0	0	1	1	1	2	1	2	1	3	3	4	4	5	3
HIGHWAY VEHICLES	0	0	0	0	1	2	4	5	6	4	9	11	15	16	24	29	33	30
OTHER	16	20	22	23	23	18	10	8	8	13	7	6	5	4	6	3	2	3
TOTAL	20	25	28	31	32	29	22	19	22	24	21	23	28	32	53	53	55	55

SUMMARY OF NOx EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR NEW JERSEY

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	4	6	8	11	14	26	24	18	25	30	42	49	59	100	103	57	56	61
INDUSTRIAL	14	22	30	38	41	60	52	44	50	48	48	56	48	56	35	22	23	29
COMMERCIAL-RESIDENTIAL	0	0	0	0	0	1	1	2	6	8	74	6	26	30	41	36	30	33
HIGHWAY VEHICLES	0	0	1	2	8	18	35	39	59	39	72	96	131	143	232	276	264	246
OTHER	76	103	119	129	136	240	266	207	168	367	98	96	71	70	88	59	61	61
TOTAL	93	131	157	180	199	345	379	309	308	492	334	303	335	400	499	449	434	429

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR NEW MEXICO

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	0	0	0	0	1	0	1	1	2	4	6	8	35	79	94	111	124
INDUSTRIAL	1	1	2	2	3	4	5	13	19	28	60	78	67	77	102	90	79	92
COMMERCIAL-RESIDENTIAL	0	0	0	1	1	1	1	1	1	1	3	2	3	3	4	4	4	4
HIGHWAY VEHICLES	0	0	0	0	0	1	2	3	4	4	11	16	27	28	40	56	64	62
OTHER	5	6	8	9	10	11	10	8	6	19	17	16	17	26	30	31	45	33
TOTAL	5	8	10	12	14	17	18	26	32	54	95	118	122	168	256	276	303	316

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR NEW YORK

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	10	17	23	30	42	70	70	48	69	92	131	145	160	201	224	170	171	153
INDUSTRIAL	55	74	93	109	114	128	111	93	116	119	102	107	96	126	92	47	55	64
COMMERCIAL-RESIDENTIAL	2	2	4	4	5	6	7	7	19	11	25	19	79	90	102	93	104	70
HIGHWAY VEHICLES	0	0	1	7	23	50	90	95	127	83	148	180	237	259	378	361	375	353
OTHER	185	242	268	280	287	302	286	227	188	287	229	217	182	152	171	106	105	88
TOTAL	251	335	388	430	471	555	564	470	519	591	635	667	755	828	966	776	810	727

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR NORTH CAROLINA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	1	2	2	4	8	10	8	14	22	37	55	62	111	218	208	220	235
INDUSTRIAL	2	4	6	8	12	19	20	18	25	29	28	30	37	50	42	32	38	41
COMMERCIAL-RESIDENTIAL	1	1	2	2	3	3	4	4	10	7	22	12	19	15	17	13	13	13
HIGHWAY VEHICLES	0	0	0	1	5	10	16	19	30	27	63	81	112	126	178	221	241	222
OTHER	29	32	35	37	38	40	39	29	25	49	47	61	43	49	56	44	44	35
TOTAL	33	38	44	50	62	80	88	78	104	134	196	238	273	351	511	517	556	546

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR NORTH DAKOTA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	1	1	1	1	2	2	1	2	2	7	6	7	7	19	32	59	76
INDUSTRIAL	1	1	2	2	2	2	1	1	1	2	4	5	5	7	21	18	19	5
COMMERCIAL-RESIDENTIAL	1	1	2	3	3	4	4	3	6	4	6	3	4	3	3	3	3	3
HIGHWAY VEHICLES	0	0	0	0	2	3	4	5	8	5	11	14	17	19	28	29	32	33
OTHER	6	9	13	16	17	15	11	9	7	18	12	13	16	14	14	15	18	21
TOTAL	7	12	17	23	26	25	22	19	23	30	40	41	49	50	85	98	131	138

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR OHIO

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	12	19	26	35	42	50	51	38	62	95	141	189	239	288	416	492	545	519
INDUSTRIAL	98	131	189	229	218	228	203	169	217	236	220	210	228	296	203	133	124	100
COMMERCIAL-RESIDENTIAL	6	9	15	19	20	22	25	20	55	36	69	37	53	47	52	47	49	12
HIGHWAY VEHICLES	0	0	1	5	17	36	57	60	90	69	131	162	213	233	333	398	410	389
OTHER	58	72	82	86	90	86	81	67	50	102	86	103	112	115	131	105	108	142
TOTAL	173	231	312	373	387	421	417	354	474	538	647	700	845	979	1,135	1,175	1,237	1,162

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR OKLAHOMA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	1	1	1	2	5	6	5	6	9	10	16	20	31	55	68	98	153
INDUSTRIAL	1	3	18	40	71	123	176	69	102	88	106	105	69	102	160	142	143	116
COMMERCIAL-RESIDENTIAL	0	1	2	3	3	4	4	3	7	4	8	5	6	6	7	8	10	8
HIGHWAY VEHICLES	0	0	0	1	5	10	19	19	26	19	39	48	67	71	106	139	156	154
OTHER	11	16	22	26	28	87	122	77	94	101	72	37	41	46	48	49	61	45
TOTAL	13	20	43	71	109	228	326	173	235	221	235	211	202	256	377	406	468	477

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR OREGON

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	0	0	0	0	5	4	4	1	3	4	4	0	0	0	1	1	12
INDUSTRIAL	1	1	2	3	2	4	3	4	5	6	8	8	14	22	18	22	25	19
COMMERCIAL-RESIDENTIAL	0	0	0	1	1	1	1	1	2	2	6	3	7	7	7	7	6	5
HIGHWAY VEHICLES	0	0	0	1	3	6	10	10	16	15	35	39	51	60	86	103	122	113
OTHER	19	21	23	24	25	80	76	67	45	130	53	50	52	46	54	49	65	76
TOTAL	20	23	26	28	31	96	94	85	69	155	107	104	124	134	166	181	218	225

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR PENNSYLVANIA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	8	13	18	24	38	65	69	47	70	97	153	182	176	247	347	392	381	443
INDUSTRIAL	89	139	271	332	348	380	317	235	272	265	208	208	217	212	163	116	125	123
COMMERCIAL-RESIDENTIAL	2	3	6	8	9	10	10	8	23	17	36	20	47	45	53	48	52	50
HIGHWAY VEHICLES	0	0	1	3	12	25	55	70	103	72	136	166	228	233	337	403	422	388
OTHER	178	234	258	273	279	256	176	140	119	213	193	217	204	184	188	167	196	166
TOTAL	276	388	553	640	685	735	628	500	587	664	726	793	873	921	1,089	1,126	1,175	1,170

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR RHODE ISLAND

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	1	2	2	3	6	5	4	5	4	7	8	7	6	4	2	2	2
INDUSTRIAL	6	7	8	9	8	12	10	9	10	8	6	9	10	4	3	2	2	2
COMMERCIAL-RESIDENTIAL	0	0	0	0	0	1	1	1	4	2	4	3	6	4	7	5	5	7
HIGHWAY VEHICLES	0	0	0	0	1	3	5	7	9	6	8	11	14	14	27	31	29	25
OTHER	15	19	21	22	22	20	13	10	9	12	8	7	5	6	8	4	3	3
TOTAL	21	28	31	33	34	41	34	30	35	33	32	39	42	33	48	44	41	38

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR SOUTH CAROLINA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	1	1	2	2	4	4	3	4	6	7	15	23	36	60	55	77	80
INDUSTRIAL	1	2	3	4	5	8	9	10	15	19	17	24	29	36	32	26	35	36
COMMERCIAL-RESIDENTIAL	0	1	1	1	2	2	2	2	4	3	11	6	8	6	7	5	6	9
HIGHWAY VEHICLES	0	0	0	1	2	5	7	9	15	13	30	40	54	63	99	125	135	125
OTHER	20	22	24	25	26	27	109	27	29	39	25	25	23	22	30	22	23	19
TOTAL	22	25	29	33	38	45	132	50	67	79	91	110	138	162	227	232	276	269

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR SOUTH DAKOTA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	1	1	2	2	2	2	2	2	4	4	4	4	3	15	23	34	29
INDUSTRIAL	1	2	2	3	2	2	2	2	4	3	3	3	3	5	2	2	3	2
COMMERCIAL-RESIDENTIAL	1	1	1	2	2	2	2	2	4	2	2	1	3	3	3	2	2	3
HIGHWAY VEHICLES	0	0	0	1	2	4	5	6	8	6	15	16	20	22	31	32	35	36
OTHER	6	8	9	10	10	10	8	7	6	13	8	11	11	11	10	10	15	8
TOTAL	9	12	14	16	18	19	20	19	24	28	31	35	42	43	61	70	90	78

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR TENNESSEE

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	2	3	4	5	6	8	9	19	35	7	68	136	127	175	260	218	238
INDUSTRIAL	9	12	14	17	19	22	23	25	36	46	58	61	52	95	66	52	72	58
COMMERCIAL-RESIDENTIAL	2	2	3	4	4	4	5	5	12	8	21	9	12	9	11	9	9	14
HIGHWAY VEHICLES	0	0	0	1	3	7	13	18	20	20	43	56	81	92	132	202	225	191
OTHER	30	33	35	36	37	38	48	36	38	59	50	50	55	61	73	78	93	74
TOTAL	42	49	55	61	67	77	97	93	125	168	179	244	336	384	456	603	618	575

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR TEXAS

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	1	2	2	5	9	16	12	16	29	40	67	96	159	249	365	533	609
INDUSTRIAL	4	5	6	12	30	92	277	278	420	536	747	780	1,252	1,473	1,207	1,186	1,154	905
COMMERCIAL-RESIDENTIAL	2	2	3	3	4	5	6	5	15	26	20	16	16	15	25	30	38	49
HIGHWAY VEHICLES	0	0	1	4	13	27	46	52	82	72	157	195	262	293	412	522	636	613
OTHER	54	60	66	67	69	359	400	309	220	483	242	204	230	222	275	357	459	356
TOTAL	60	69	77	88	120	492	744	656	752	1,147	1,207	1,262	1,856	2,162	2,168	2,459	2,820	2,532

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR UTAH

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	0	0	0	0	0	0	0	1	1	2	8	9	7	8	22	34	54
INDUSTRIAL	2	3	4	6	7	8	9	10	14	17	28	29	19	29	14	23	27	20
COMMERCIAL-RESIDENTIAL	1	1	2	2	3	3	3	3	6	4	4	2	4	4	4	6	5	11
HIGHWAY VEHICLES	0	0	0	0	1	1	2	3	5	4	11	13	19	23	34	42	48	50
OTHER	4	6	7	8	8	10	10	9	7	14	27	26	29	28	36	44	43	45
TOTAL	7	10	13	16	18	22	24	24	32	40	72	79	80	90	95	136	157	181

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR VERMONT

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	1	1	1	2	2	1	1	1	1	0	1	0	1	1	0	0	0
INDUSTRIAL	2	3	4	5	5	5	4	3	3	3	1	1	1	1	1	1	1	1
COMMERCIAL-RESIDENTIAL	0	0	0	0	0	0	0	0	1	1	1	1	2	2	3	2	3	3
HIGHWAY VEHICLES	0	0	0	0	1	2	3	3	5	3	7	8	10	11	15	20	21	19
OTHER	14	18	19	20	20	16	8	6	7	10	5	5	5	3	4	3	3	4
TOTAL	16	22	24	26	27	24	16	14	17	18	14	15	18	18	24	26	28	27

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR VIRGINIA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	2	3	4	6	7	9	10	8	13	20	34	41	70	96	95	74	84	74
INDUSTRIAL	8	12	17	22	23	23	23	24	35	43	46	47	50	67	55	40	35	50
COMMERCIAL-RESIDENTIAL	1	1	2	3	3	3	4	5	14	10	23	12	20	16	21	16	16	23
HIGHWAY VEHICLES	0	0	0	1	4	8	14	17	27	24	54	70	99	117	171	207	212	200
OTHER	29	34	39	42	45	57	71	49	38	94	52	64	57	68	95	76	80	84
TOTAL	40	51	62	73	82	101	122	101	126	190	209	235	296	364	437	412	428	431

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR WASHINGTON

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	0	1	1	1	1	2	1	1	1	1	2	2	0	0	0	39	52	53
INDUSTRIAL	2	3	4	5	6	8	7	7	8	12	15	18	28	39	28	29	32	25
COMMERCIAL-RESIDENTIAL	1	1	1	2	2	3	3	2	5	4	8	4	11	10	11	9	9	16
HIGHWAY VEHICLES	0	0	0	1	4	9	15	16	24	22	41	48	63	68	120	139	159	149
OTHER	16	21	26	29	30	68	69	57	30	72	48	46	50	55	51	57	80	73
TOTAL	19	25	32	38	44	91	95	83	67	111	113	117	153	171	210	273	332	317

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR WEST VIRGINIA

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	2	3	4	5	9	18	20	15	23	34	45	73	65	93	159	276	285	311
INDUSTRIAL	10	17	62	78	82	66	55	46	64	66	78	74	61	114	67	59	53	46
COMMERCIAL-RESIDENTIAL	0	1	2	2	3	3	3	2	7	4	9	5	6	5	11	6	7	13
HIGHWAY VEHICLES	0	0	0	1	2	5	8	10	15	12	26	30	39	40	58	65	63	62
OTHER	12	16	19	22	24	24	30	19	15	30	21	20	23	19	22	23	34	37
TOTAL	24	35	86	108	120	115	116	91	123	145	179	203	194	271	316	429	442	469

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR WISCONSIN

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	3	4	6	8	9	11	11	8	14	23	34	47	58	80	126	127	138	150
INDUSTRIAL	14	20	25	30	38	51	48	40	51	55	26	25	51	83	63	38	36	42
COMMERCIAL-RESIDENTIAL	3	4	6	8	8	9	10	8	18	11	13	7	30	27	26	22	23	36
HIGHWAY VEHICLES	0	0	0	2	7	15	26	25	36	30	57	68	89	96	148	172	192	170
OTHER	39	46	50	52	54	49	44	27	21	39	38	41	41	40	52	39	39	38
TOTAL	59	75	87	100	115	134	137	109	140	157	167	188	269	326	414	397	429	435

SUMMARY OF NOX EMISSIONS (1000 TONS) BY SOURCE CATEGORY FOR WYOMING

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1978	1980
ELECTRIC UTILITIES	1	1	1	2	2	2	1	1	1	2	3	4	9	22	40	76	127	169
INDUSTRIAL	2	3	3	3	8	29	25	7	10	10	15	27	17	19	62	36	53	49
COMMERCIAL-RESIDENTIAL	1	1	1	1	1	1	1	1	2	2	2	1	1	2	2	2	3	3
HIGHWAY VEHICLES	0	0	0	0	0	1	1	2	3	2	7	9	13	14	19	26	32	31
OTHER	4	5	5	5	5	16	15	13	11	22	20	22	29	28	34	39	51	72
TOTAL	7	9	10	10	16	48	44	24	27	39	46	64	69	85	158	180	267	323

APPENDIX C

ILLUSTRATIVE EXAMPLE OF HISTORIC TOTAL SO_2 AND NO_X EMISSIONS UNCERTAINTY

TABLE C-1. SO2 ACTIVITY UNCERTAINTY (percent)

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980
STATIONARY SOURCE FUEL COMBUSTION																	
BITUMINOUS COAL	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
ANTHRACITE	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
RESIDUAL OIL	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
DISTILLATE OIL	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
NATURAL GAS	150	150	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
WOOD	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
TRANSPORTATION																	
HIGHWAY VEHICLES	100	100	100	100	100	50	50	50	50	50	25	25	25	25	25	25	25
RAILROADS - OIL	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
- COAL	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
VESSELS - OIL	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
OTHER OFF-HIGHWAY USE	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
MISCELLANEOUS																	
- COPPER	75	75	75	75	75	75	75	75	75	75	15	15	15	15	15	15	15
- LEAD	75	75	75	75	75	75	75	75	75	75	75	75	75	15	15	15	15
- ZINC	75	75	75	75	75	75	75	75	75	75	75	75	75	15	15	15	15
COKE PLANT	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
CEMENT PLANTS	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
WILDFIRES	125	125	125	125	125	125	25	25	25	25	25	25	25	25	25	25	25
MISC. OTHER SOURCES	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30

TABLE C-2. SO2 EMISSION FACTOR UNCERTAINTY (percent)

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980
STATIONARY SOURCE FUEL COMBUSTION																	
BITUMINOUS COAL	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
ANTHRACITE	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
RESIDUAL OIL	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
DISTILLATE OIL	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
NATURAL GAS	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
WOOD	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
TRANSPORTATION	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
HIGHWAY VEHICLES	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
RAILROADS - OIL	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
- COAL	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
VESSELS - OIL	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
OTHER OFF-HIGHWAY USE	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
MISCELLANEOUS	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
SMELTERS - COPPER	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
- LEAD	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
- ZINC	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
COKE PLANT	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
CEMENT PLANTS	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
WILDFIRES	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25
MISC. OTHER SOURCES	57	57	56	55	54	53	52	51	50	48	45	40	35	30	25	25	25

TABLE C-3. SULFUR CONTENT UNCERTAINTY (percent)

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980
STATIONARY SOURCE FUEL COMBUSTION																	
BITUMINOUS COAL	43	43	43	42	46	39	40	41	43	43	44	45	41	39	37	40	50
ANTHRACITE	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
RESIDUAL OIL	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67
DISTILLATE OIL	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67
NATURAL GAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WOOD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRANSPORTATION																	
HIGHWAY VEHICLES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RAILROADS - OIL	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67
- COAL	43	43	43	42	46	39	40	41	43	43	44	45	41	39	37	40	50
VESSELS - OIL	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67
OTHER OFF-HIGHWAY USE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS																	
SMELTERS - COPPER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- LEAD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- ZINC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COKE PLANTS	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
CEMENT PLANTS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WILDFIRES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MISC. OTHER SOURCES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE C-4. SO2 SOURCE CATEGORY UNCERTAINTY (percent)

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980
STATIONARY SOURCE FUEL COMBUSTION																	
BITUMINOUS COAL	75	74	73	72	74	69	69	69	69	67	66	63	56	52	48	50	50
ANTHRACITE	80	79	78	78	77	76	76	75	74	72	71	67	64	61	59	59	59
RESIDUAL OIL	93	93	92	91	90	90	89	88	88	86	84	81	79	76	74	74	74
DISTILLATE OIL	93	92	92	91	90	90	89	88	88	86	84	81	79	76	74	74	74
NATURAL GAS	169	168	58	57	56	55	54	53	52	50	48	43	38	34	29	29	29
WOOD	60	59	58	57	56	55	54	53	52	50	48	43	38	34	29	29	29
TRANSPORTATION																	
HIGHWAY VEHICLES	121	120	119	119	118	74	74	73	72	70	52	48	43	39	36	36	36
RAILROADS - OIL	96	95	94	94	93	92	92	91	91	89	87	84	82	79	77	77	77
- COAL	78	77	77	77	77	72	72	72	73	70	69	67	60	56	52	54	62
VESSELS - OIL	96	95	94	94	93	92	92	91	91	89	87	84	82	79	77	77	77
OTHER OFF-HIGHWAY USE	63	62	62	61	60	59	58	57	56	54	52	48	43	39	36	36	36
MISCELLANEOUS																	
SMELTERS - COPPER	98	97	97	96	95	95	94	94	93	91	48	43	38	34	29	29	29
- LEAD	98	97	97	96	95	95	94	94	93	91	48	43	38	34	29	29	29
- ZINC	98	97	97	96	95	95	94	94	93	91	90	87	84	34	29	29	29
COKE PLANTS	87	87	86	85	85	84	83	83	82	80	79	75	72	70	68	68	68
CEMENT PLANTS	60	59	58	57	56	55	54	53	52	50	48	43	38	34	29	29	29
WILDFIRES	144	144	143	143	142	141	58	57	56	54	52	48	43	39	36	36	36
MISC. OTHER SOURCES	66	65	64	63	62	61	61	60	59	57	55	51	47	43	39	39	39

TABLE C-5. NO_x ACTIVITY UNCERTAINTY (percent)

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980
STATIONARY SOURCE FUEL COMBUSTION																	
BITUMINOUS COAL	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
ANTHRACITE	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
RESIDUAL OIL	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
DISTILLATE OIL	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
NATURAL GAS	150	150	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
WOOD	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
TRANSPORTATION																	
HIGHWAY VEHICLES	100	100	100	100	100	50	50	50	50	50	25	25	25	25	25	25	25
RAILROADS - OIL	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
- COAL	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
VESSELS - OIL	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
OTHER OFF-HIGHWAY USE	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
MISCELLANEOUS																	
SMELTERS - COPPER	75	75	75	75	75	75	75	75	75	75	15	15	15	15	15	15	15
- LEAD	75	75	75	75	75	75	75	75	75	75	15	15	15	15	15	15	15
- ZINC	75	75	75	75	75	75	75	75	75	75	75	75	75	15	15	15	15
COKE PLANT	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
CEMENT PLANTS	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
WILDFIRES	125	125	125	125	125	125	25	25	25	25	25	25	25	25	25	25	25
MISC. OTHER SOURCES	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30

TABLE C-6. NO_x EMISSION FACTOR UNCERTAINTY (percent)

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980
STATIONARY SOURCE FUEL COMBUSTION																	
BITUMINOUS COAL	63	61	59	58	56	55	53	52	50	48	45	40	35	30	25	25	25
ANTHRACITE	63	61	59	58	56	55	53	52	50	48	45	40	35	30	25	25	25
RESIDUAL OIL	63	61	59	58	56	55	53	52	50	48	45	40	35	30	25	25	25
DISTILLATE OIL	63	61	59	58	56	55	53	52	50	48	45	40	35	30	25	25	25
NATURAL GAS	63	61	59	58	56	55	53	52	50	48	45	40	35	30	25	25	25
WOOD	63	61	59	58	56	55	53	52	50	48	45	40	35	30	25	25	25
TRANSPORTATION																	
HIGHWAY VEHICLES	78	76	74	72	70	68	66	64	62	59	56	50	43	37	31	31	31
RAILROADS - OIL	78	76	74	72	70	68	66	64	62	59	56	50	43	37	31	31	31
- COAL	78	76	74	72	70	68	66	64	62	59	56	50	43	37	31	31	31
VESSELS - OIL	78	76	74	72	70	68	66	64	62	59	56	50	43	37	31	31	31
OTHER OFF-HIGHWAY USE	78	76	74	72	70	68	66	64	62	59	56	50	43	37	31	31	31
MISCELLANEOUS																	
SMELTERS - COPPER	63	61	59	58	56	55	53	52	50	48	45	40	35	30	25	25	25
- LEAD	63	61	59	58	56	55	53	52	50	48	45	40	35	30	25	25	25
- ZINC	63	61	59	58	56	55	53	52	50	48	45	40	35	30	25	25	25
COKE PLANT	63	61	59	58	56	55	53	52	50	48	45	40	35	30	25	25	25
CEMENT PLANTS	63	61	59	58	56	55	53	52	50	48	45	40	35	30	25	25	25
WILDFIRES	63	61	59	58	56	55	53	52	50	48	45	40	35	30	25	25	25
MISC. OTHER SOURCES	63	61	59	58	56	55	53	52	50	48	45	40	35	30	25	25	25

TABLE C-7. NOx SOURCE CATEGORY UNCERTAINTY (percent)

SOURCE CATEGORY	1900	1905	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980
STATIONARY SOURCE FUEL COMBUSTION																	
BITUMINOUS COAL	65	63	61	60	58	57	55	54	52	50	48	43	38	34	29	29	29
ANTHRACITE	65	63	61	60	58	57	55	54	52	50	48	43	38	34	29	29	29
RESIDUAL OIL	65	63	61	60	58	57	55	54	52	50	48	43	38	34	29	29	29
DISTILLATE OIL	65	63	61	60	58	57	55	54	52	50	48	43	38	34	29	29	29
NATURAL GAS	172	171	61	60	58	57	55	54	52	50	48	43	38	34	29	29	29
WOOD	65	63	61	60	58	57	55	54	52	50	48	43	38	34	29	29	29
TRANSPORTATION																	
HIGHWAY VEHICLES	135	133	132	130	129	87	85	84	82	79	62	56	51	45	40	40	40
RAILROADS - OIL	82	80	79	77	75	73	71	69	68	65	62	56	51	45	40	40	40
- COAL	82	80	79	77	75	73	71	69	68	65	62	56	51	45	40	40	40
VESSELS - OIL	82	80	79	77	75	73	71	69	68	65	62	56	51	45	40	40	40
OTHER OFF-HIGHWAY USE	82	80	79	77	75	73	71	69	68	65	62	56	51	45	40	40	40
MISCELLANEOUS																	
SMELTERS - COPPER	102	101	99	98	97	96	95	94	93	91	48	43	38	34	29	29	29
- LEAD	102	101	99	98	97	96	95	94	93	91	48	43	38	34	29	29	29
- ZINC	102	101	99	98	97	96	95	94	93	91	90	87	84	34	29	29	29
COKE PLANTS	65	63	61	60	58	57	55	54	52	50	48	43	38	34	29	29	29
CEMENT PLANTS	65	63	61	60	58	57	55	54	52	50	48	43	38	34	29	29	29
WILDFIRES	148	147	146	145	144	143	59	58	56	54	52	48	43	39	36	36	36
MISC. OTHER SOURCES	70	69	67	66	65	63	62	60	59	57	55	51	47	43	39	39	39